AD-A103 377 ARMY ELECTRONICS RESEARCH AND DEVELOPMENT COMMAND WS--ETC F/G 20/6
LIDAR OBSERVATIONS AT 0.7 MICROMETER AND 10.6 MICROMETER WAVELE--ETC(U)
JUL 80 J S RANDHAWA
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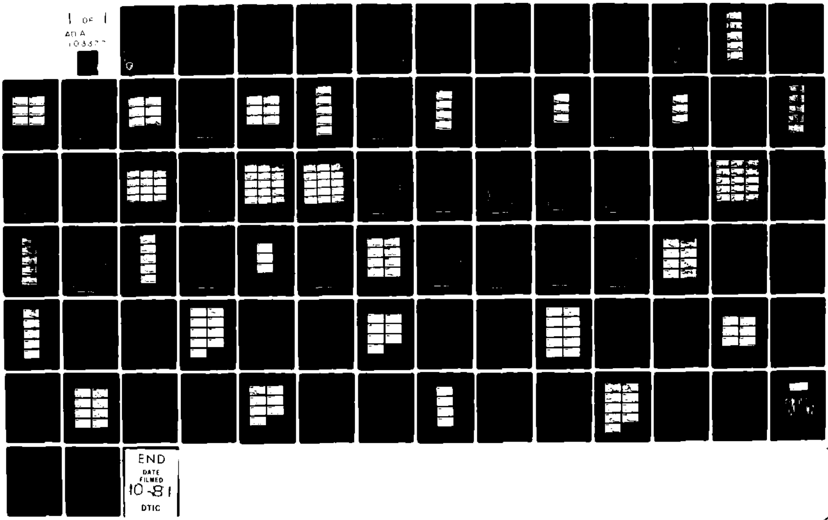

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LIDAR OBSERVATIONS AT 0.7µm AND 10.6µm WAVELENGTHS DURING DUSTY INFRARED TEST I (DIRT-I)

ADDITIONAL RESULTS.

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BY

J. S. RANDHAWA

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US Army Electronics Research and Development Command
ATMOSPHERIC SCIENCES LABORATORY
White Sands Missile Range, NM 88002

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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Lidar	Transmission
Obscuration	Dust clouds
Smoke clouds	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Two wavelength lidar measurements were made during the Dusty Infrared Test-I (DIRT-I) program conducted at White Sands Missile Range (WSMR) in October 1978. This report contains the additional results obtained during the test but not published in an earlier report.

CONTENTS

1. INTRODUCTION

The Dusty Infrared Test I (DIRT-I) was held at White Sands Missile Range (WSMR) in October 1978 to evaluate various techniques to measure physical and optical properties of battlefield dust. Since lidar technique represents one of the most promising techniques, two lidar systems: 10.6µm wavelength (ASL-lidar) and 0.7µm Ruby lidar system (Mark IX), were operated over a common 2-km optical path during this test. Primary lidar backscatter data for both wavelengths were recorded on magnetic tape by using Mark IX lidar data system[1] while independent 10.6µm lidar transmission data were recorded on strip chart in the ASL lidar van. Photographs were also taken every 30 to 60 seconds during each event of range-resolved 10.6µm backscatter amplitude data (A-Scope presentation). In an earlier report[2] a few results were described along with the experimental setup, calibration and operating procedures, and analysis technique. This report contains the rest of the results obtained during the test.

2. EXPERIMENT

The two lidar systems were positioned as shown in figure 1. Static TNT charges, artillery rounds, live artillery barrages, and an oil and rubber fire generated dust and smoke cloud in a test zone midway (1 km) between the lidar systems and a beam-stop lidar target.[3] Specifications for the 10.6µm lidar are given in table 1. Table 2 is an inventory and summary of the data collected during the DIRT-I program. In addition to the above data, television video records (video tape) of the lidar optical path were made during each event.

3. DATA

Data gathered by the two lidar systems are presented in figures 2 through 74. Data from October 2 through October 12 show only 10.6µm lidar backscatter and transmission, with the exception of event C-2 which shows the difference between the Ruby and CO_2 optical depths. Data taken on October 13 and 14 are presented under three categories for each event: (a) 10.6µm backscatter, (b) percent transmission as observed by the two-wavelengths system, and (c) optical depth difference (Ruby and CO_2).

---

[1]E. E. Uthe and R. J. Allen, 1975, "A Digital Read Time lidar Data Recording, Processing, and Display System," Optical and Quantum Electronics, 7:121

[2]Jan E. Van der laan, 1979, Lidar Observations at 0.7µm and 10.6µm Wavelengths during Dusty Infrared Test-I (DIRT-I), ASL-CR-79-0001-2, US Army Atmospheric Sciences Laboratory, White Sands Missile Range, NM

[3]James D. Lindberg, 1979, Measured Effects of Battlefield Dust and Smoke on Visible, Infrared and Millimeter Wavelength Propagation: A Preliminary Report on Dusty Infrared Test-I (DIRT-I), ASL Technical Report 0021, White Sands Missile Range, NM

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4. CONCLUSIONS

Results of the DIRT-I program as presented in the earlier report indicate that the broad particle size distribution present in the dust generated at White Sands produces little if any wavelength-dependent transmission effects. The few observed exceptions, where greater 10.6μm transmission is indicated, generally can be explained by the presence of wavelength-dependent smoke (which was also generated by the detonations) along the optical path.

TABLE 1. ASL LIDAR SPECIFICATIONS

System Component	Specification	Comments
<u>Transmitter</u>		
Manufacturer	Lumonics Research Ltd., Model TEA-101-2	
Type	CO_2	
Wavelength	10.6μm	
Beam diameter	3.1 cm	
Beam divergence	1.2 mrad	
Operation	pulsed	
Energy	250 mJ	No nitrogen gas mix
Pulsewidth	75 ns (FWHM)	
PRF (maximum)	1 pps	
<u>Receiver</u>		
Telescope	12-inch (30 cm), Newtonian	
Field of view	1.23 mrad	
Detector	Honeywell Associates; HgCdTe photodiode; $D^* = 1.3 \times 10^{10} \mathrm{cmHz}^{\frac{1}{2}}\mathrm{W}^{-1}$; 100 MHz BW	LN_2-cooled
Postamplifier	Linear: 26 dB gain, 100 MHz BW Log: tangential sensitivity -111 dBr; ±0.5 dB linearity over 80-dB range; 15-ns rise time	

TABLE 2. LIDAR DATA INVENTORY

Date	Event	Data* 1	2	3	4	5	Comments
Oct. 2	A-1	X	✓	✓	✓	✓	X = not available;
	A-2	X	✓	✓	✓	✓	Mark IX not on site
	A-3	X	✓	✓	✓	✓	✓ = data available
	A-4	X	✓	✓	✓	✓	
Oct. 3	B-1	†	✓	✓	✓	✓	† = 0.7 μm data only;
	B-2	†	✓	✓	✓	✓	two-wavelength inter-
	B-3	†.	✓	✓	✓	✓	face not complete
	B-4	†	✓	✓	✓	✓	
	B-5	†	✓	✓	✓	✓	
	B-6	†	✓	✓	✓	✓	
	B-7	†	✓	✓	✓	✓	
	B-8	†	✓	✓	✓	✓	
Oct. 5	C-1	✓	✓	✓	✓	✓	
Oct. 6	D-1	✓	✓	✓	✓	X	X = not available;
	D-2	✓	✓	✓	✓	X	ASL lidar digitizer
	D-3	✓	✓	✓	✓	X	malfunction
	D-4	✓	✓	✓	✓	X	
Oct. 10	C-2	✓	✓	✓	✓	✓	
Oct. 11	E-1	✓	✓	✓	✓	✓	
	E-2	✓	✓	✓	✓	✓	
	E-3	✓	✓	✓	✓	✓	
	E-4	✓	✓	✓	✓	✓	
Oct. 12	F-1	✓	✓	✓	✓	X	X = not available
	F-2	✓	✓	✓	✓	X	ASL lidar digitizer
	F-3	✓	✓	✓	✓	X	malfunction
	F-4	-X	-X	-X	-X	-X	-X (F-4) = live 155
Oct. 13	F-5	✓	✓	✓	✓	✓	mm rounds missed test
	F-6	✓	✓	✓	✓	✓	zone
	F-7	✓	✓	✓	✓	✓	
	F-8	✓	✓	✓	✓	✓	
Oct. 14	E-5	✓	✓	✓	✓	✓	
	E-6	✓	✓	✓	✓	✓	
	E-7	✓	✓	✓	✓	✓	
	E-8	✓	✓	✓	✓	✓	
	E-9	✓	✓	✓	✓	✓	
	E-10	✓	✓	✓	✓	✓	
Oct. 14	G-1	✓	✓	X	✓	✓	

* 1. Digitized 0.7 and 10.6 μm range-resolved backscatter data; 9-track magnetic tape.
2. 10.6 μm target return amplitude data; strip chart recordings.
3. 10.6 μm digitized target return data; IBM card/tape format.
4. 10.6 μm energy output; strip chart recordings.
5. 10.6 μm range-resolved backscatter; (A-scope) photographs; polaroid sequence.

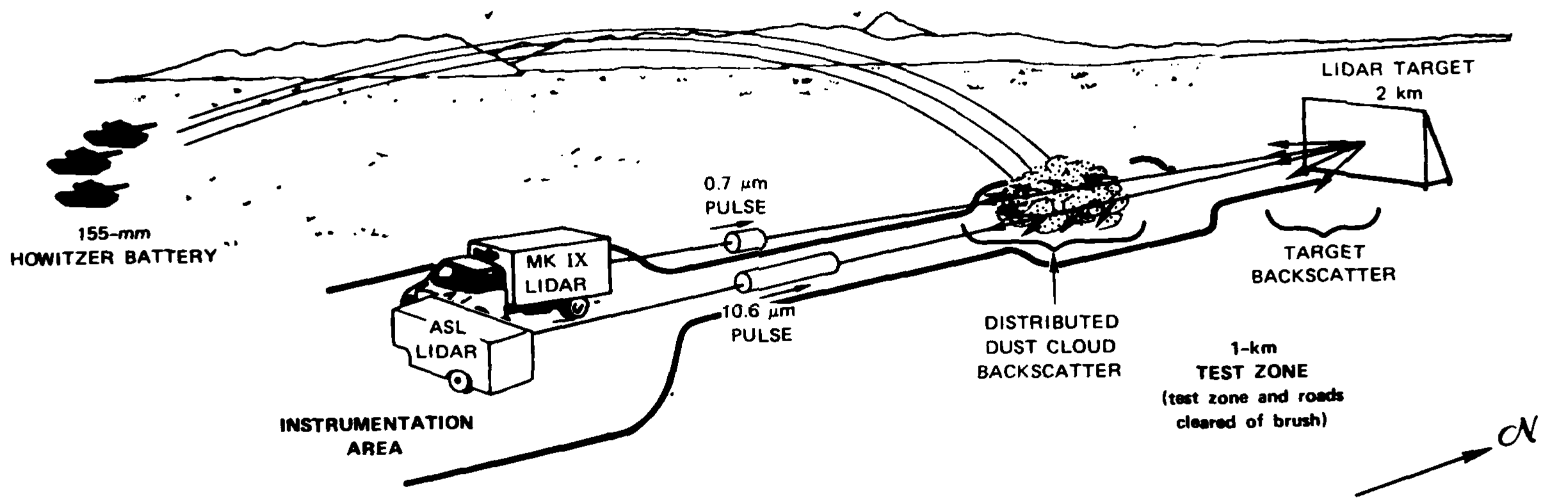


Figure 1. Experimental configuration for two-wavelength lidar observations - DIRT-I.

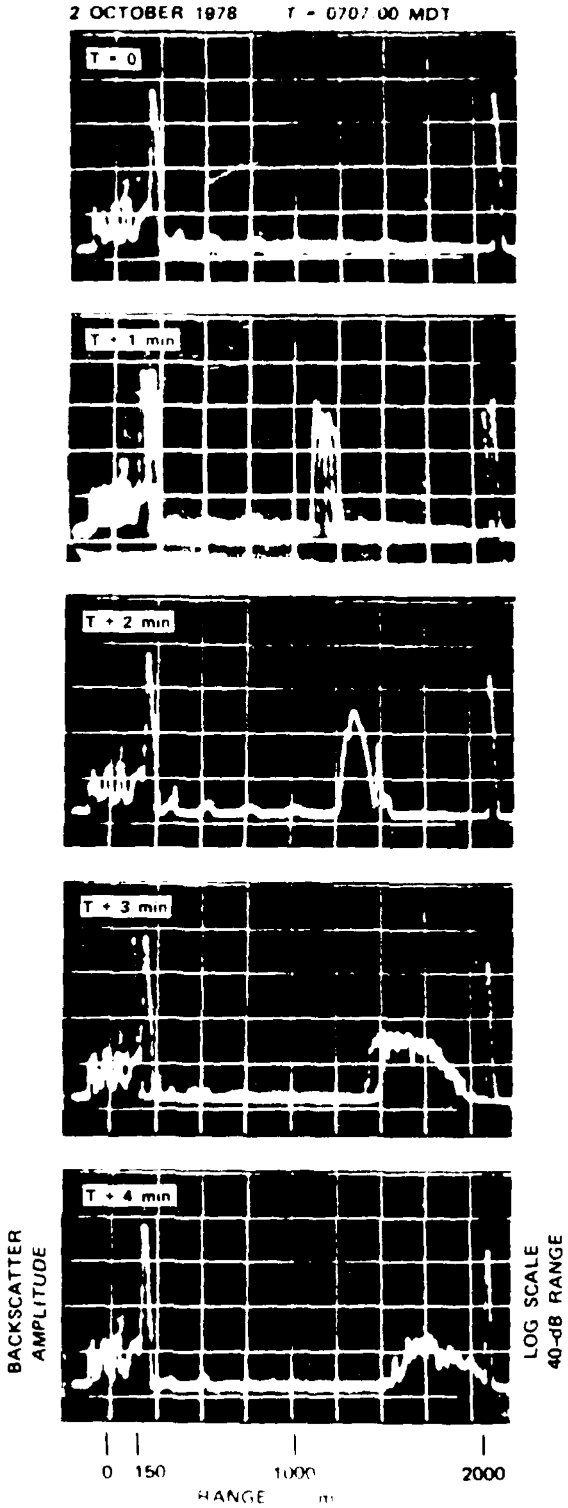


Figure 2. Event A-1 10.6 μm backscatter data.

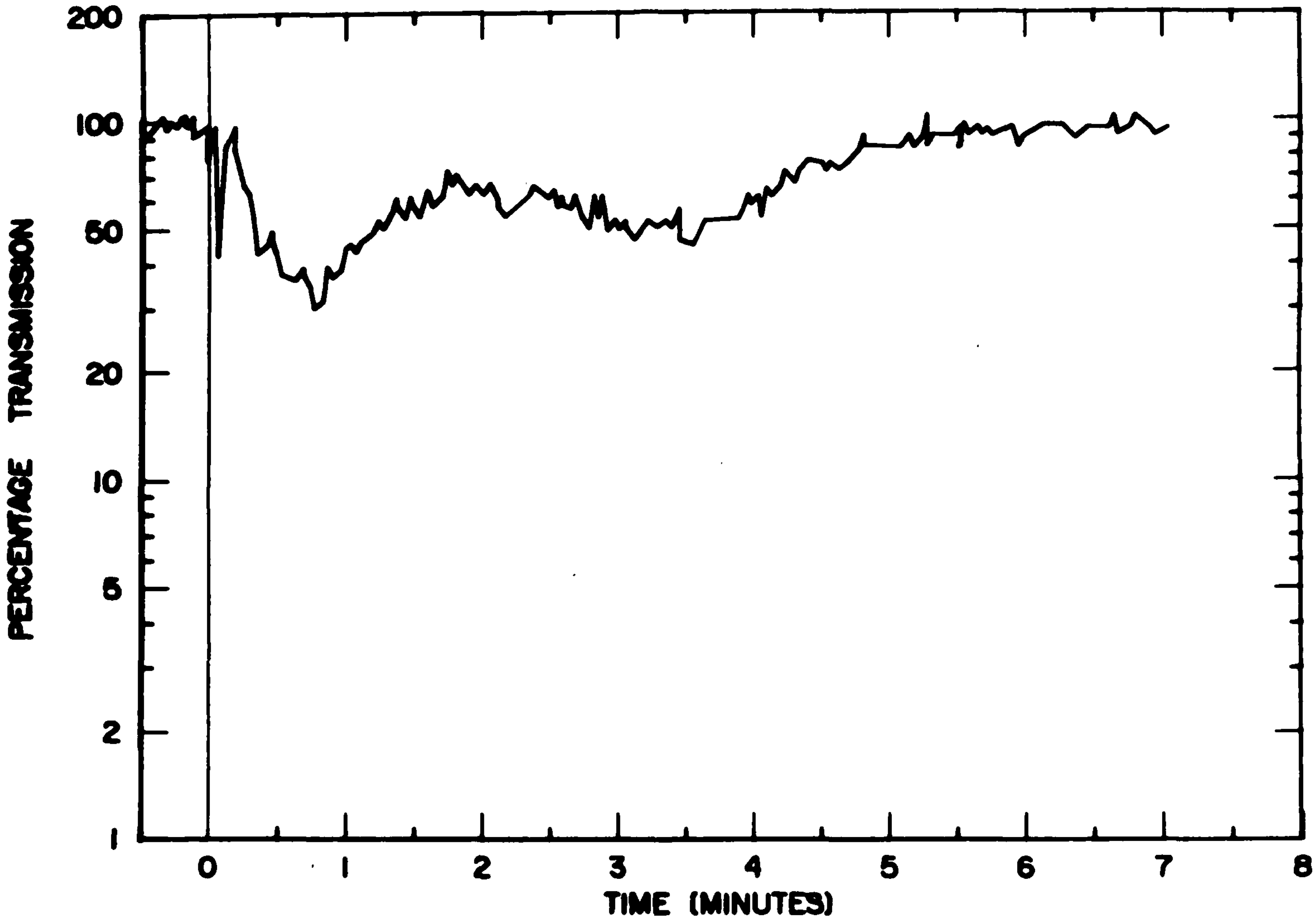


Figure 3. Event A-1 10.6μm transmission.

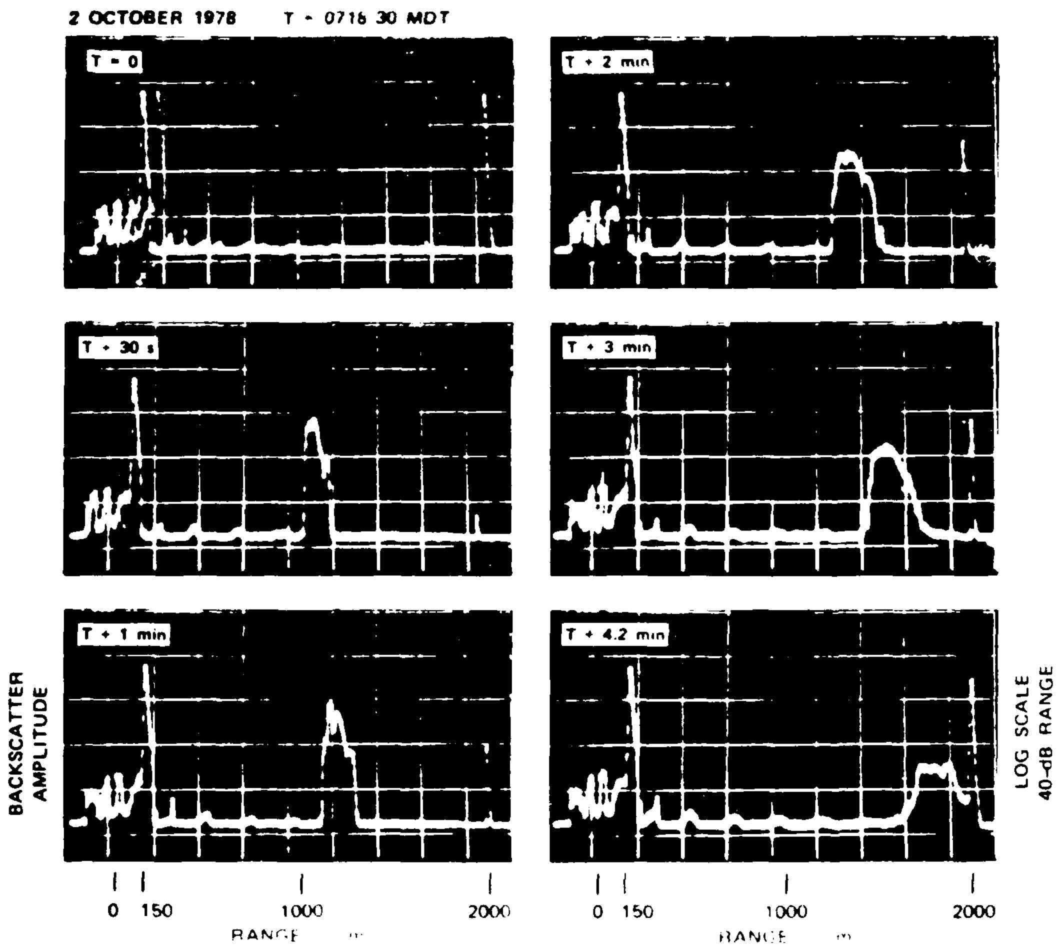


Figure 4. Event A-2 10.6μm backscatter data.

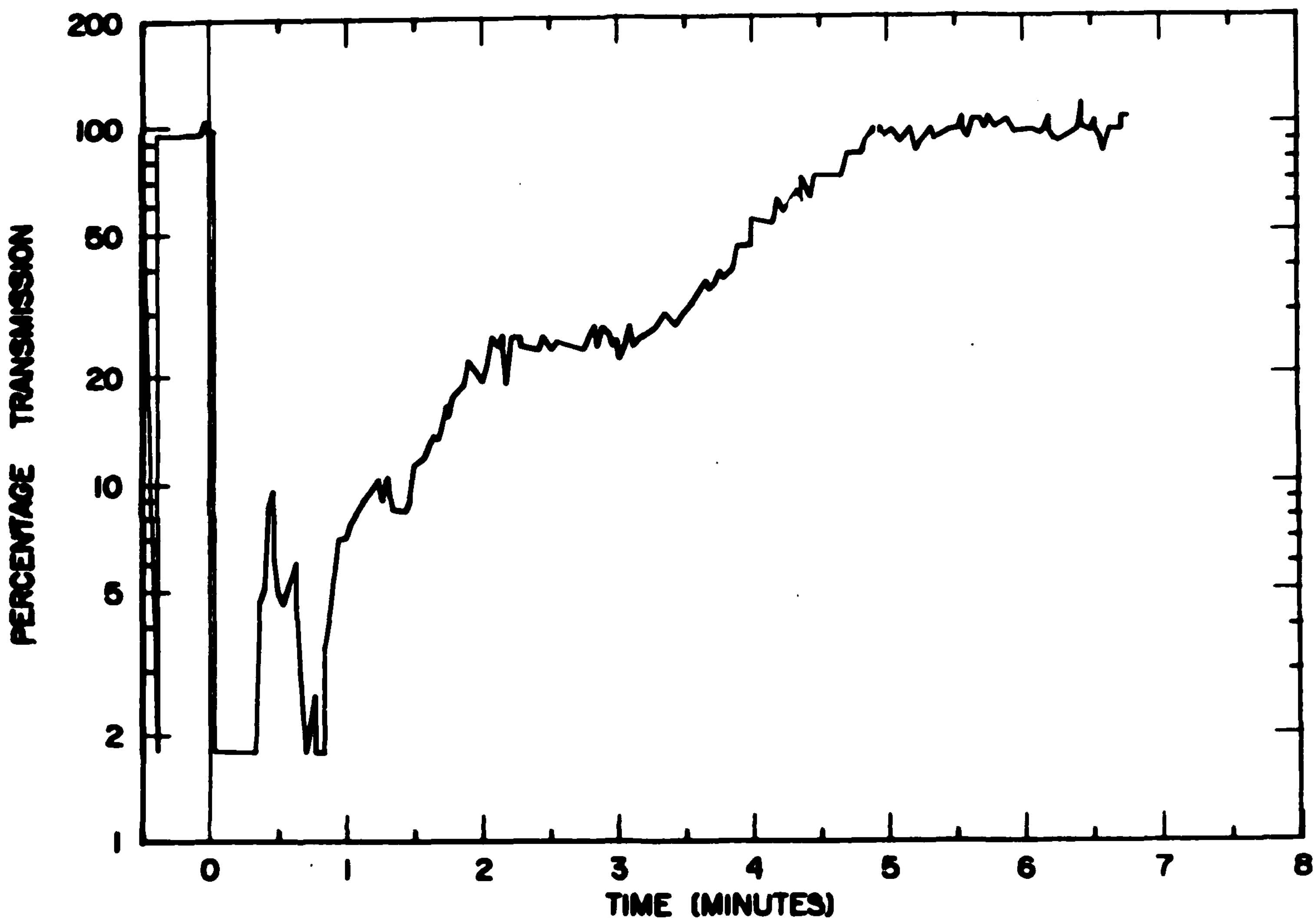


Figure 5. Event A-2 10.6μm transmission.

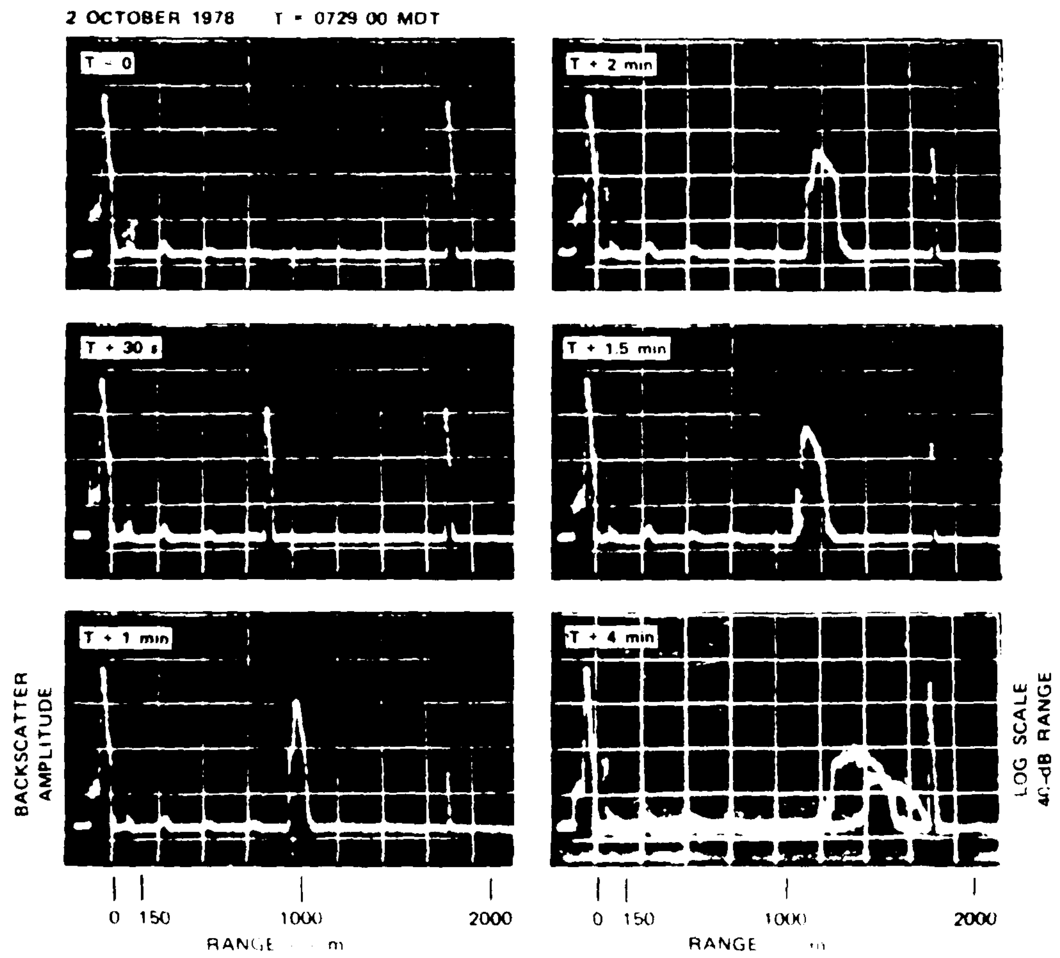


Figure 6. Event A-3 10.6 μm backscatter data.

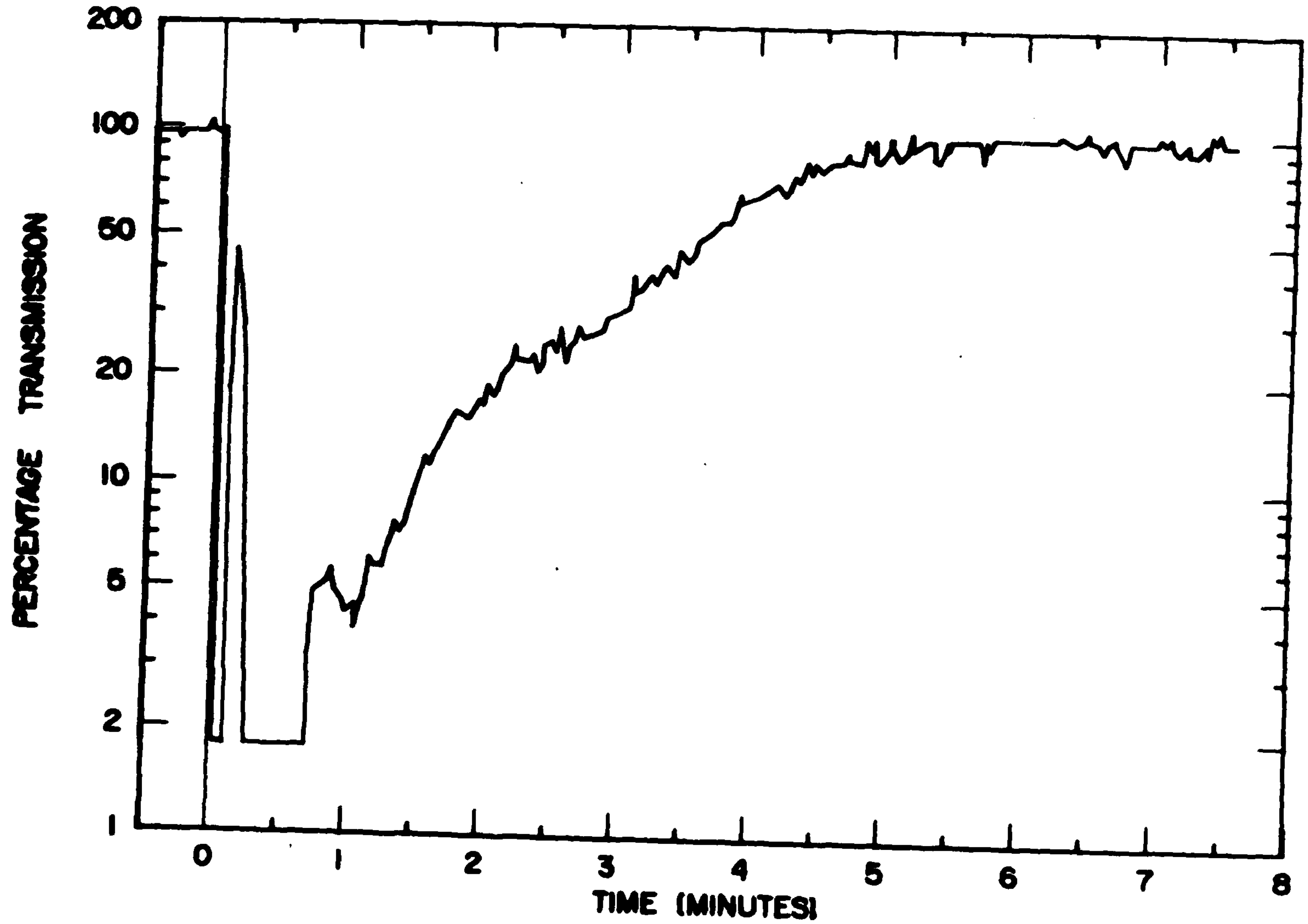


Figure 7. Event A-3 10.6μm transmission.

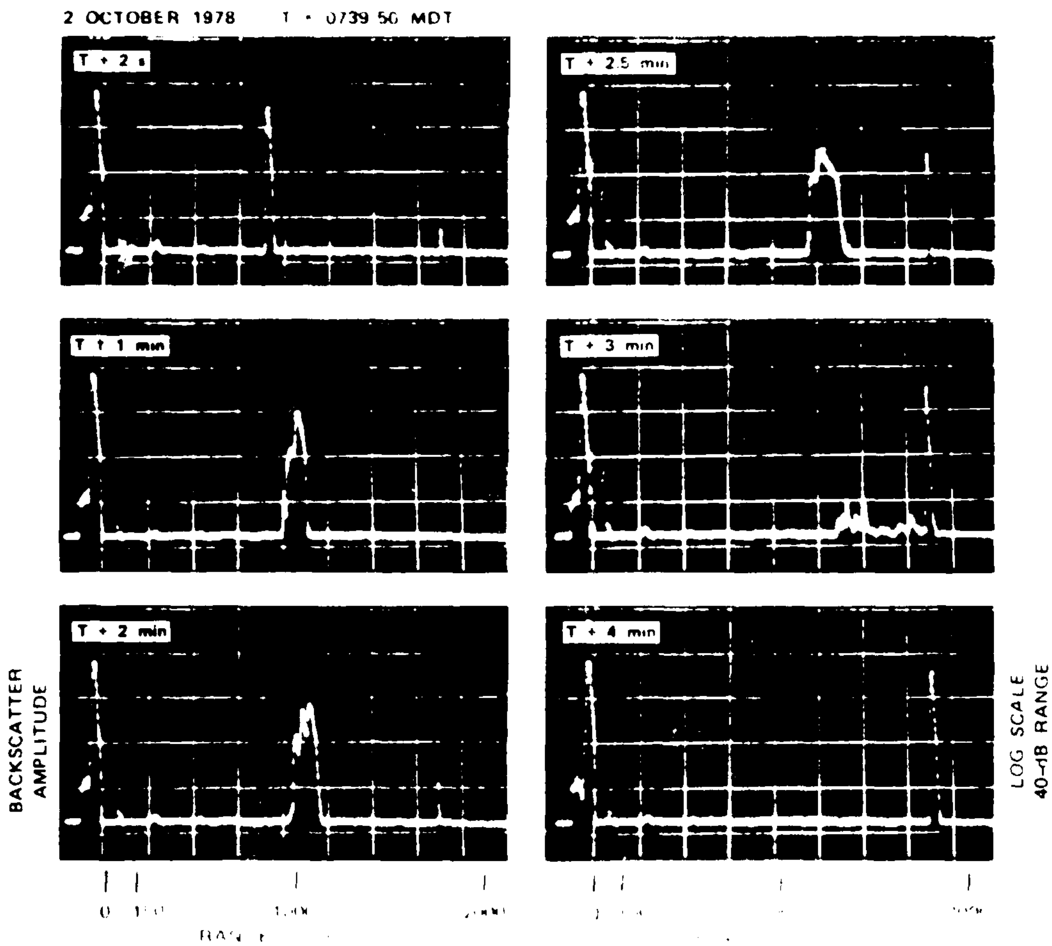


Figure 8. [illegible] 10.6 μm [illegible]

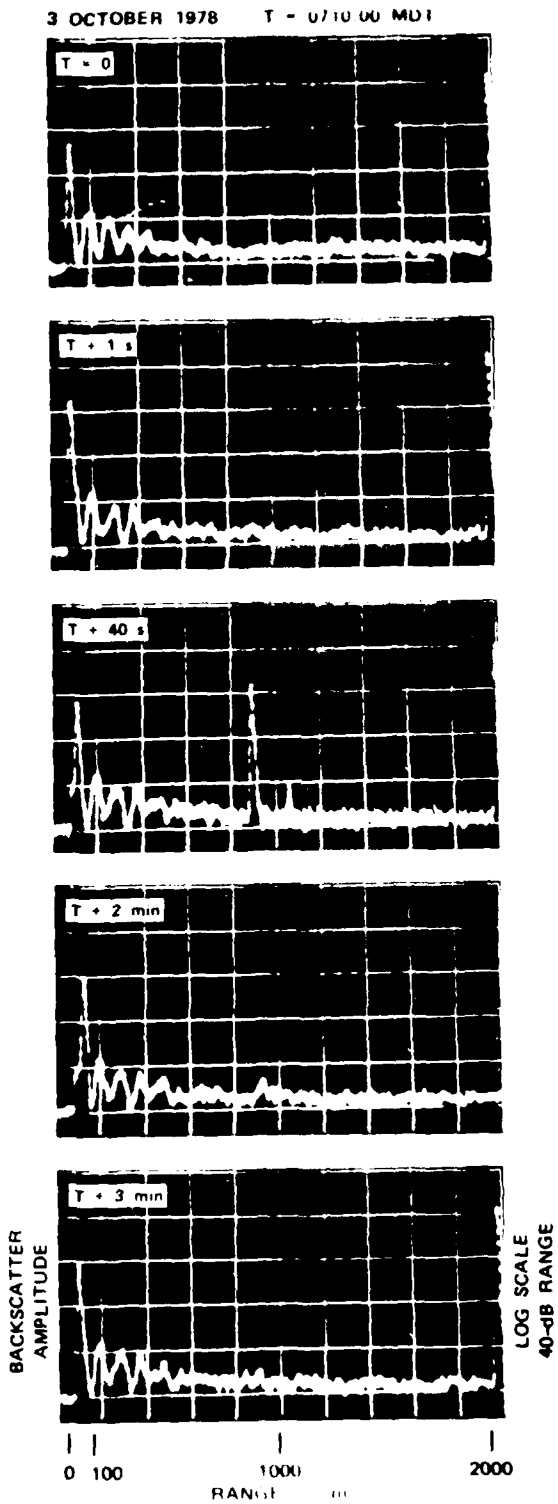


Figure 9. Event B-1 10.6μm backscatter data.

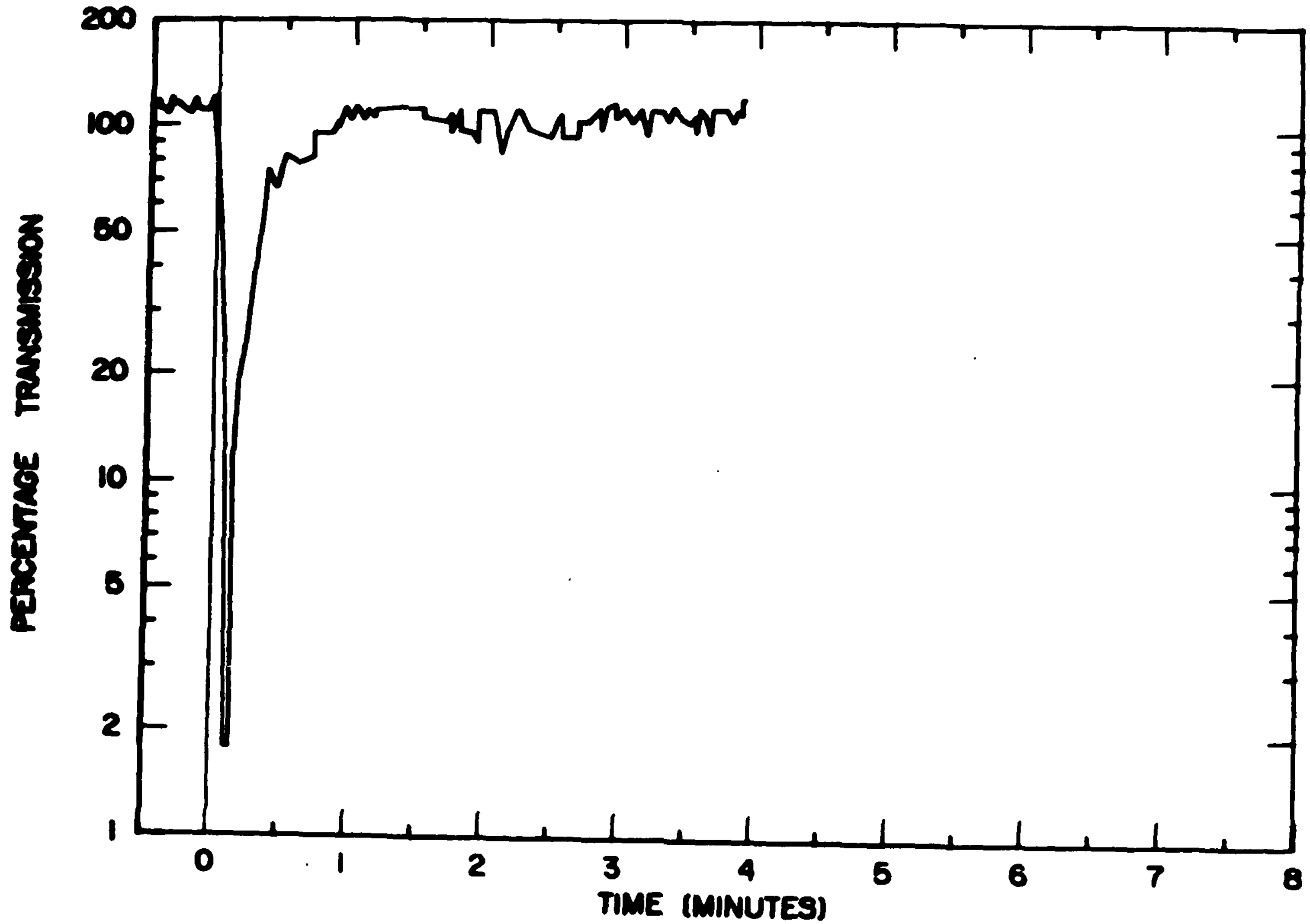


Figure 10. Event B-1 10.6μm transmission.

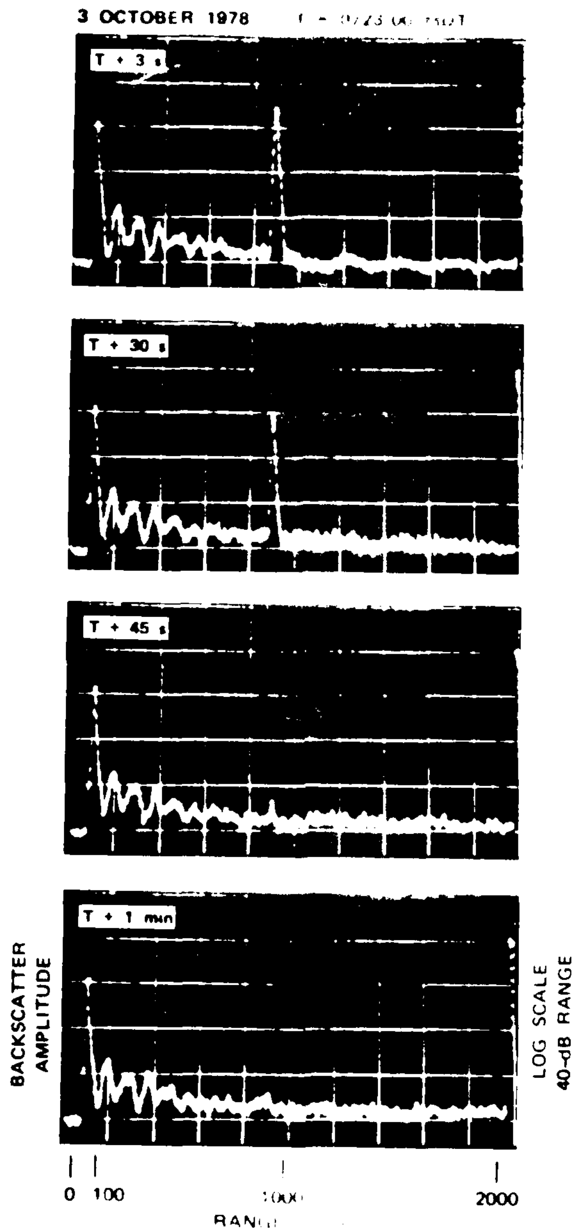


Figure 11. Event B... backscatter data.

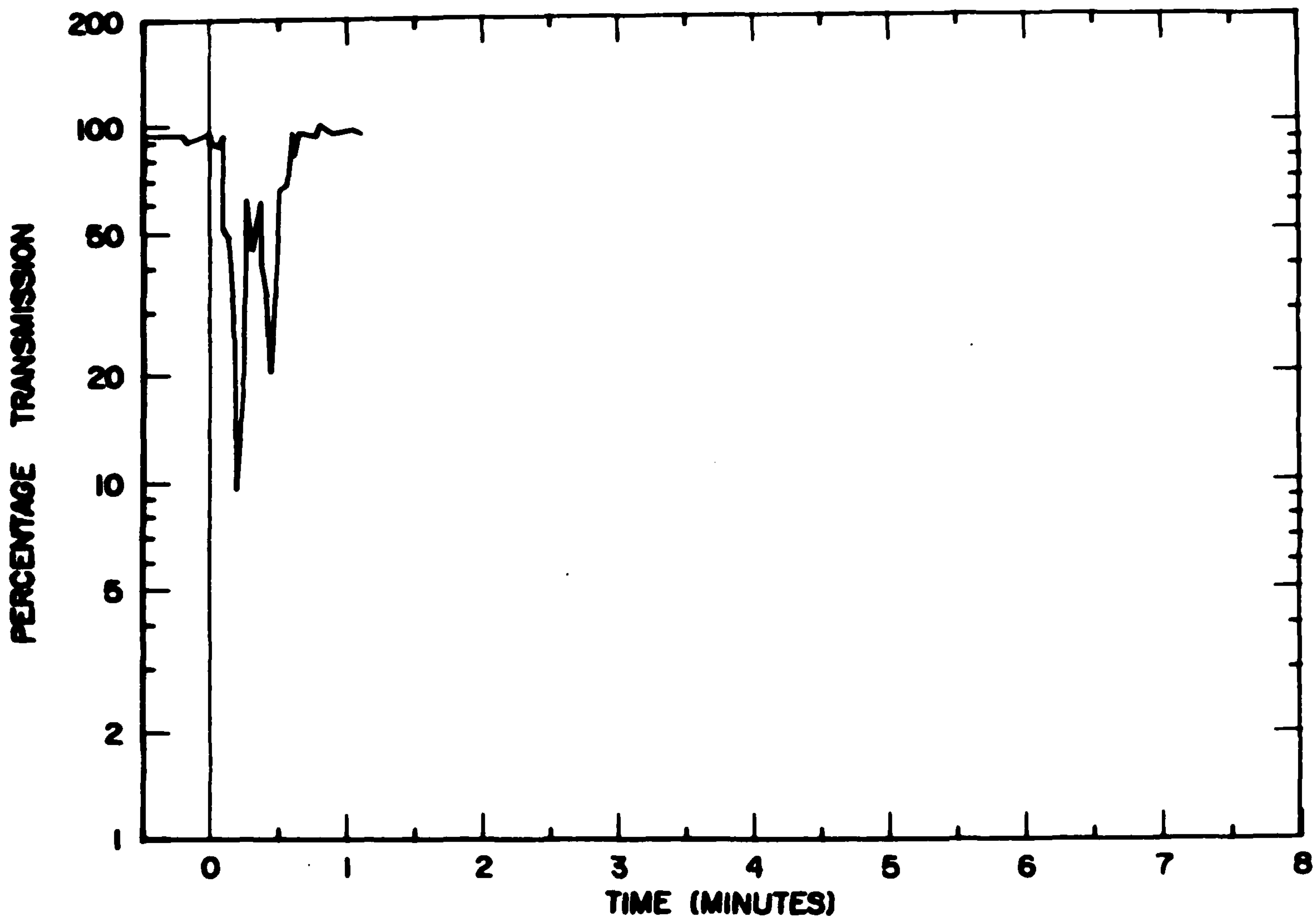


Figure 12. Event B-2 10.6μm transmission.

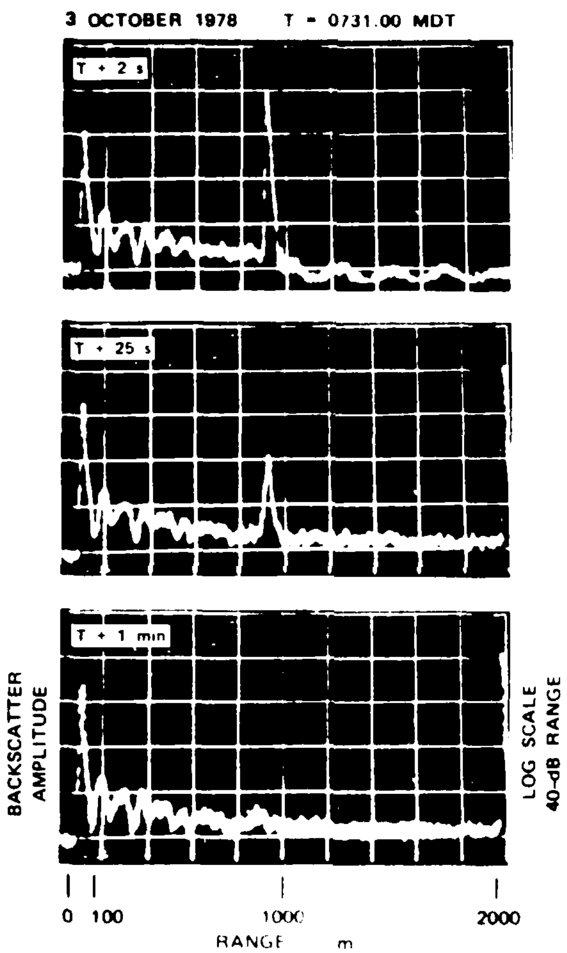


Figure 13. Event B-3 10.6μm backscatter data.

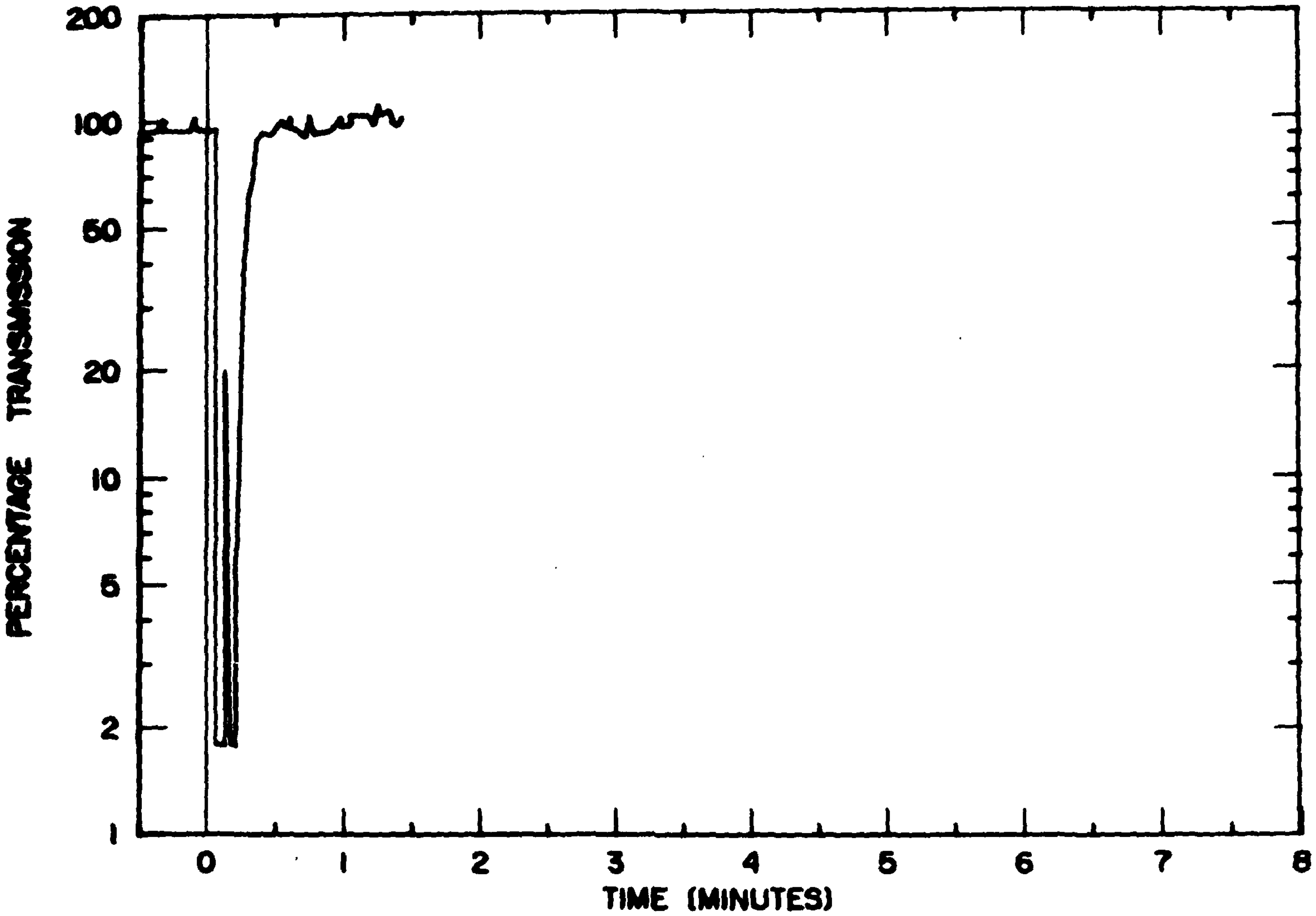


Figure 14. Event B-3 10.6μm transmission.

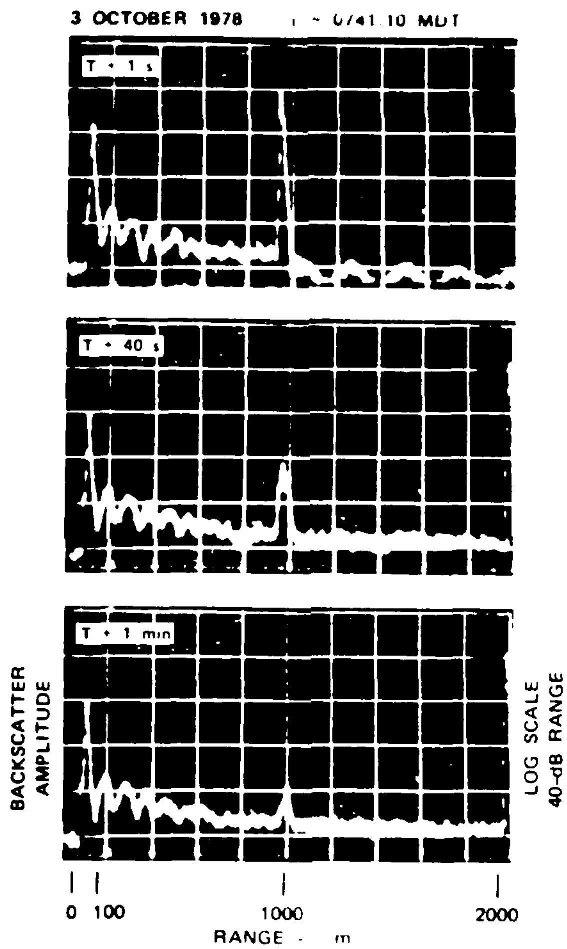


Figure 15. Event B-4 10.6μm backscatter data.

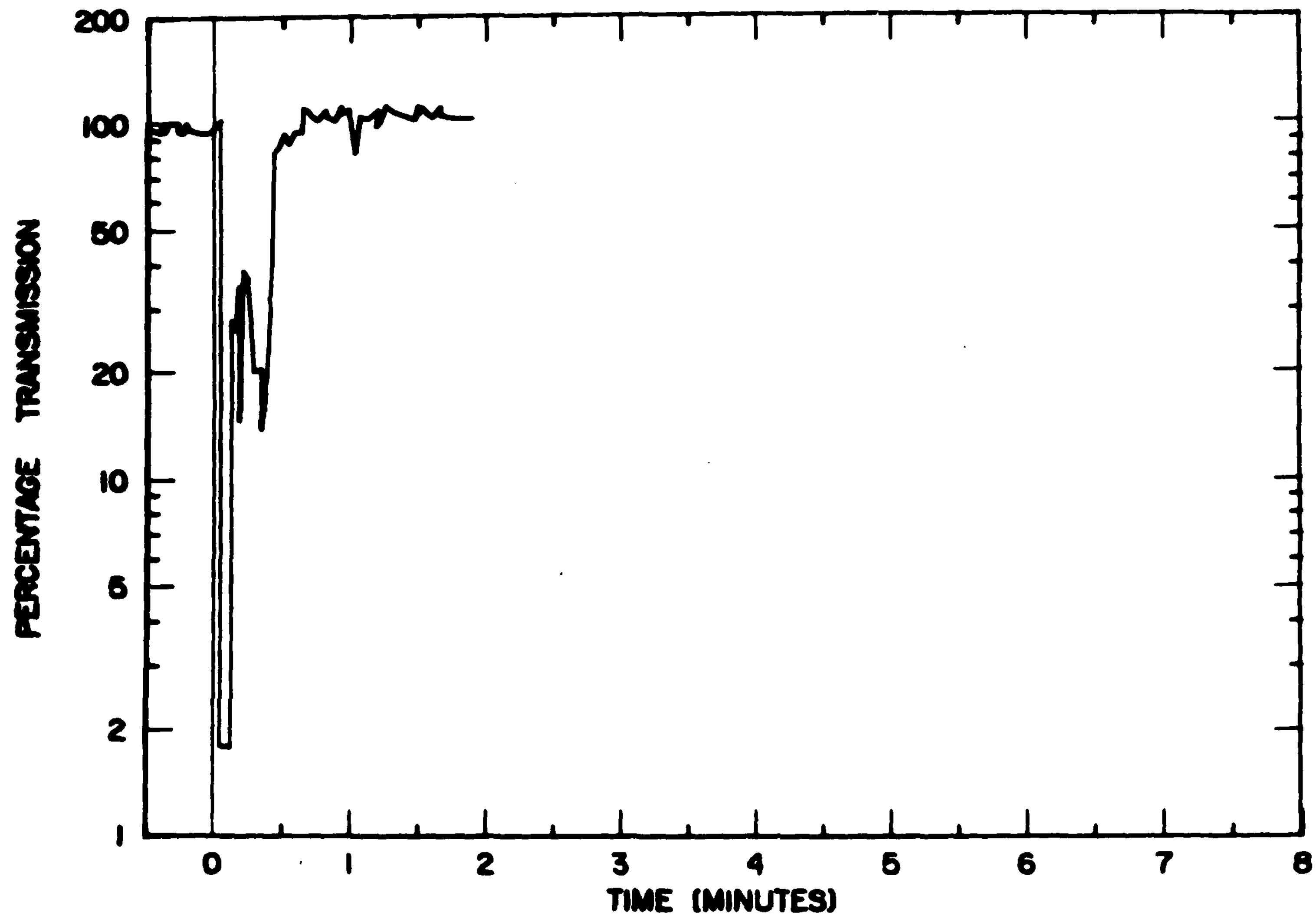


Figure 16. Event B-4 10.6μm transmission.

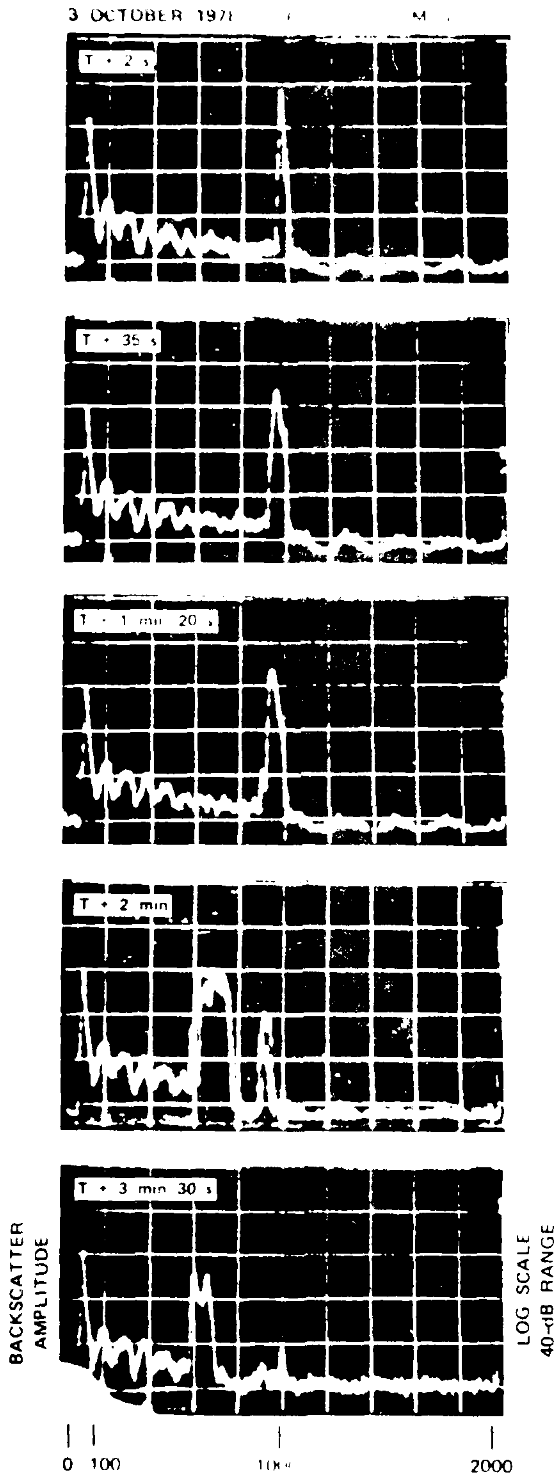


Figure 1-. [illegible] atter data.

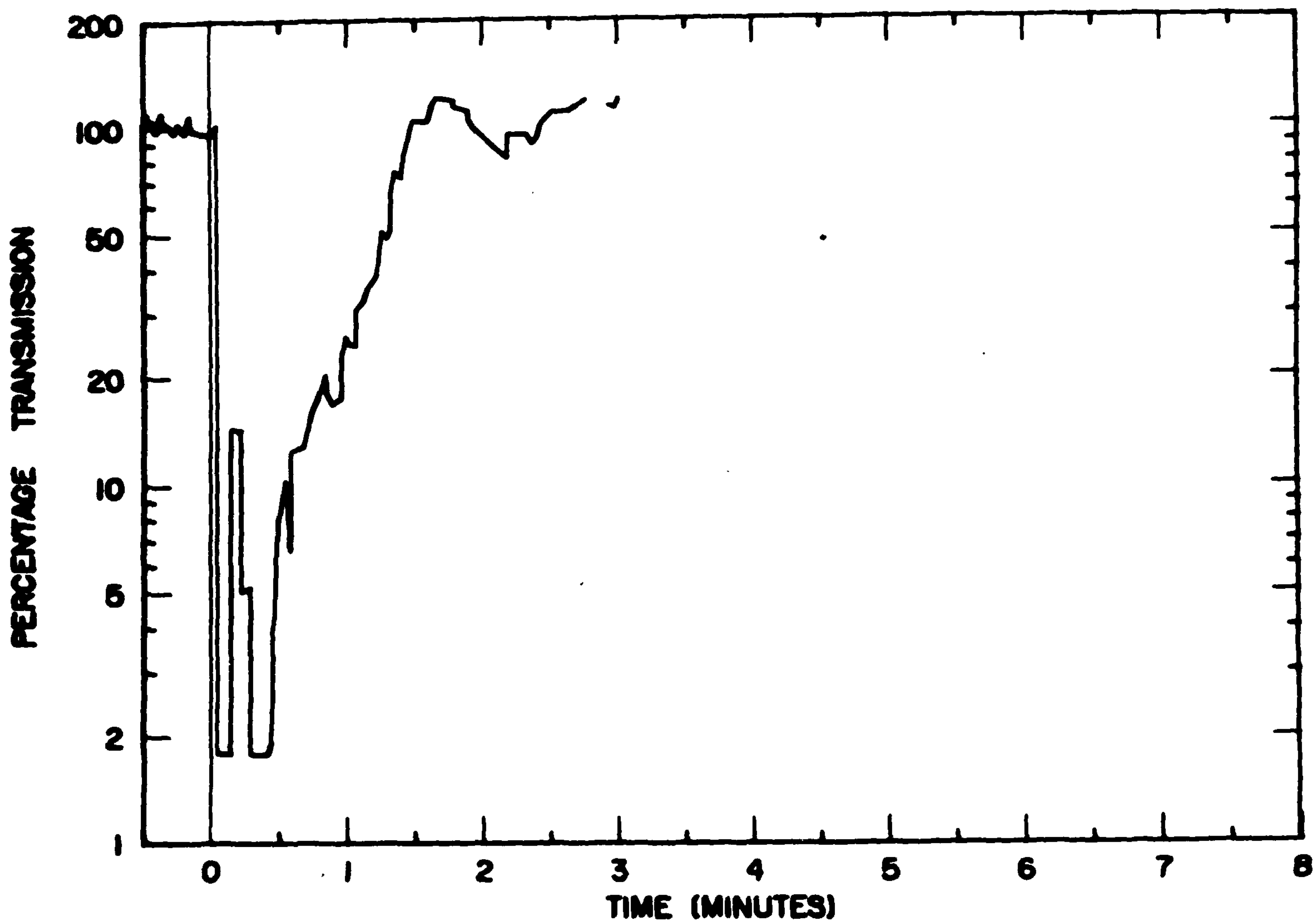


Figure 18. Event B-5 10.6μm transmission.

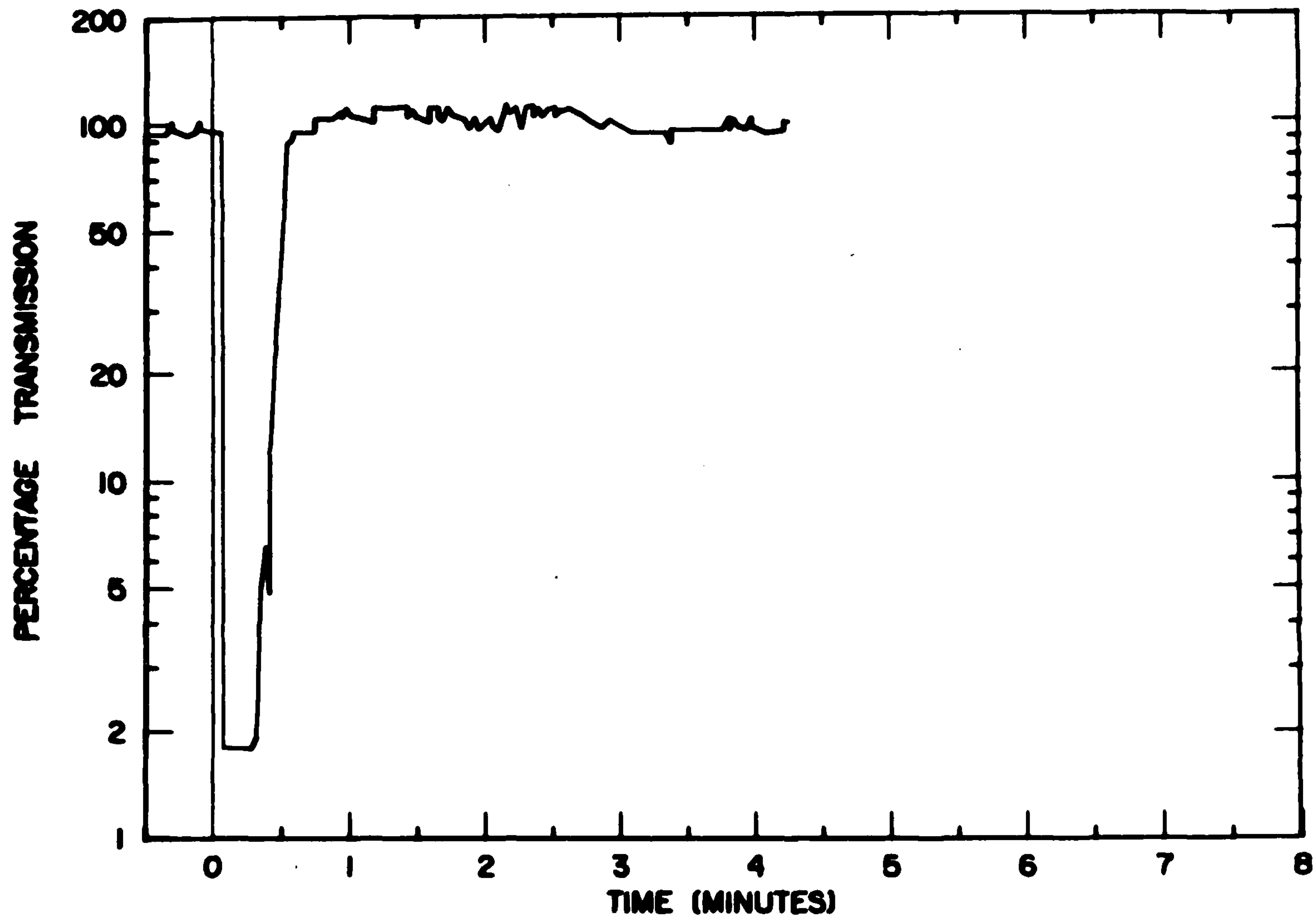
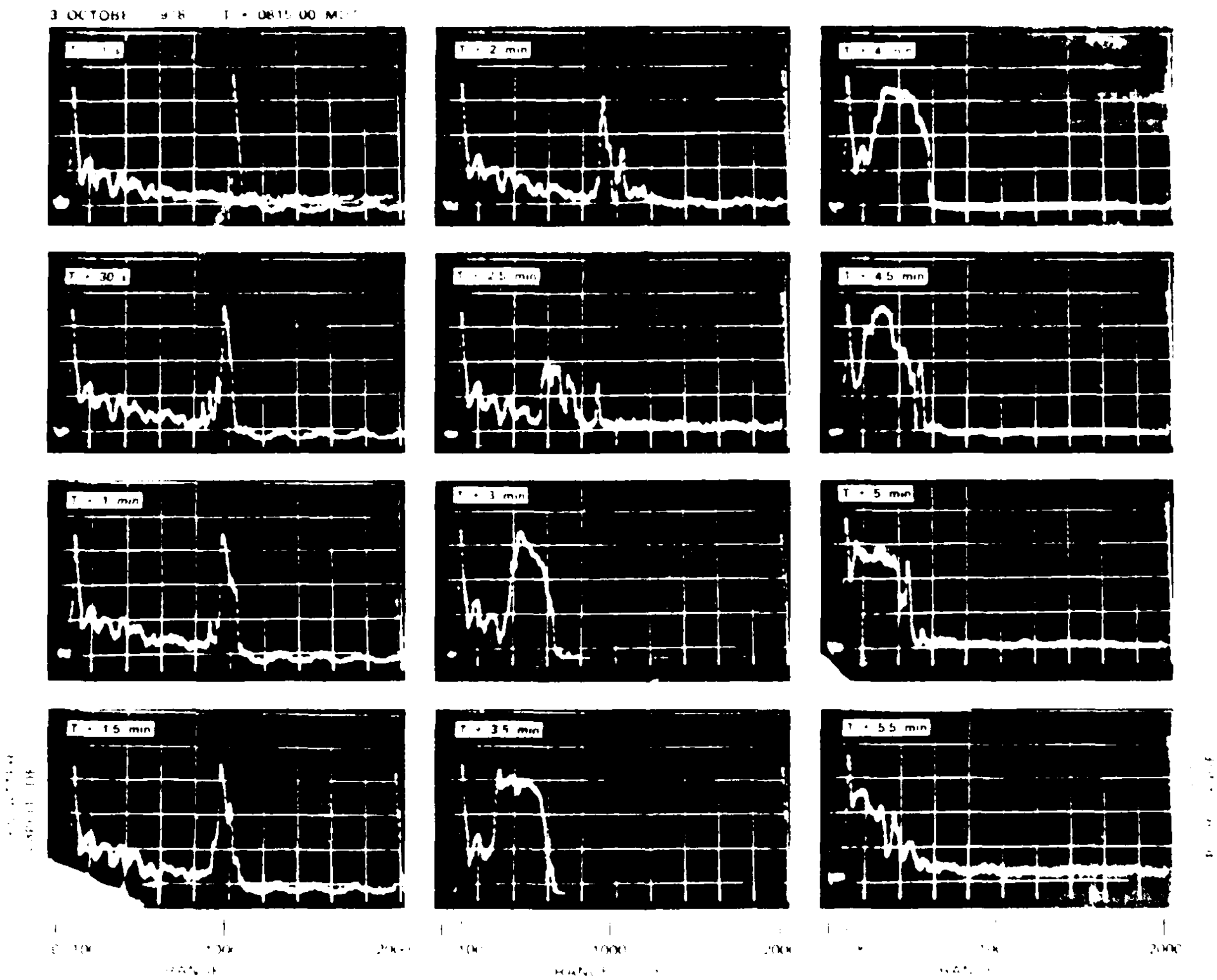


Figure 19. Event B-6 10.6μm transmission.


3 OCTOBE
0815 00
T + 2 min
T + 4 min
T + 30 s
T + 2.5 min
T + 4.5 min
T + 1 min
T + 3 min
T + 5 min
T + 1.5 min
T + 3.5 min
T + 5.5 min
1000
2000
2000

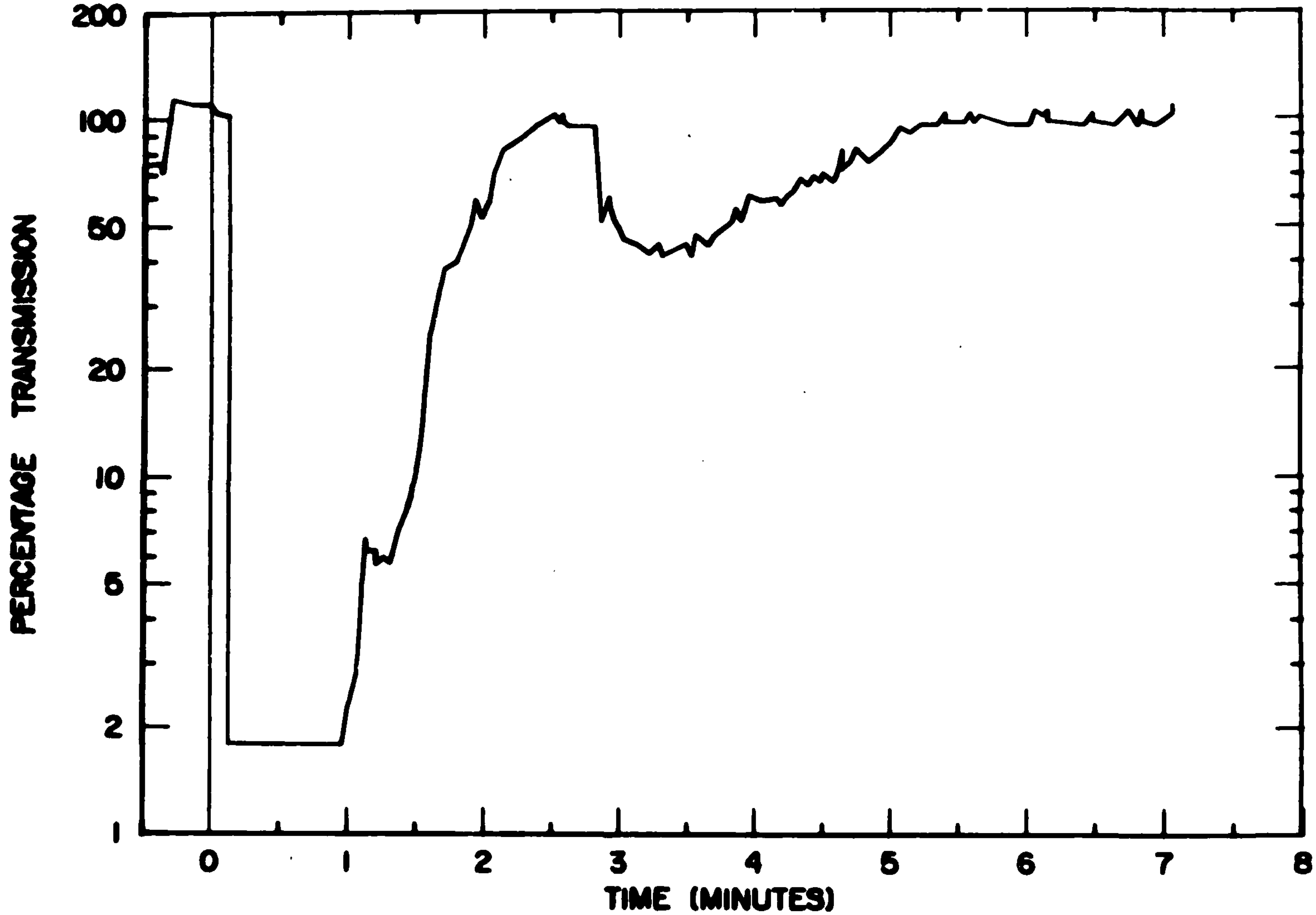
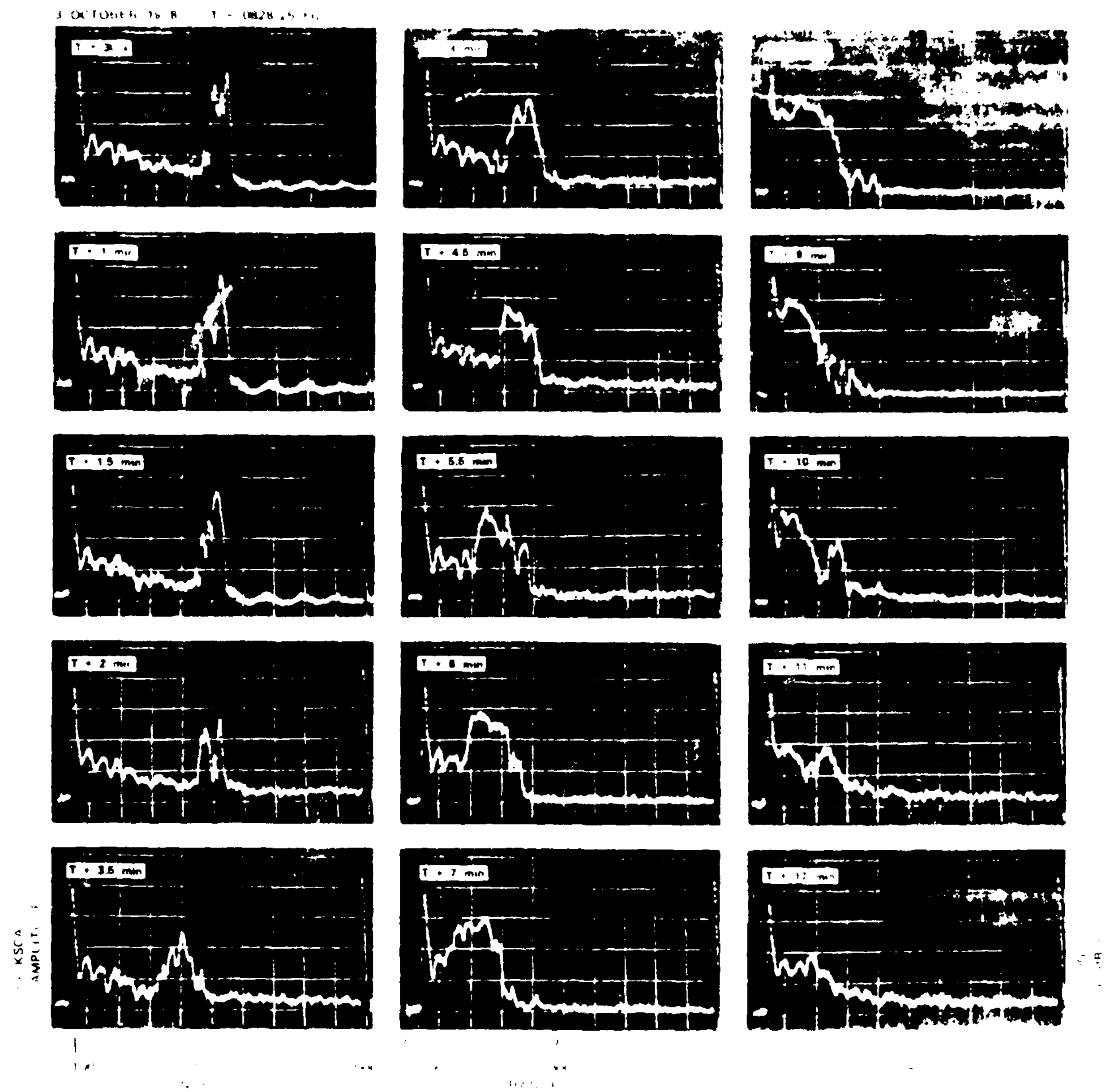
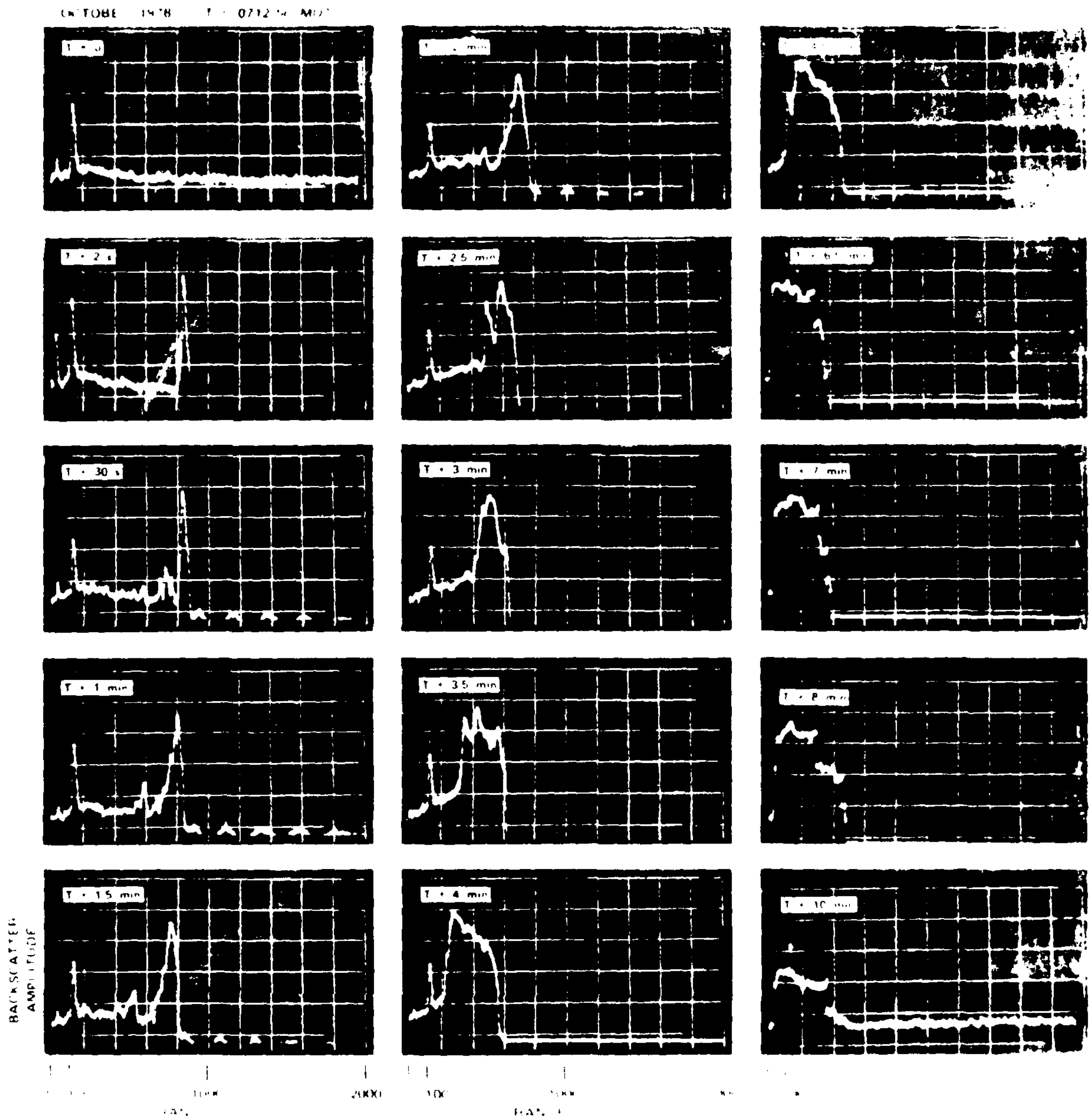


Figure 21. Event B-7 10.6μm transmission.



T + 1 min
T + 4.5 min
T + 1.5 min
T + 5.5 min
T + 10 min
T + 2 min
T + 6 min
T + 3.5 min
T + 7 min


T + 2 s
T + 30 s
T + 1 min
T + 1.5 min
T + 2.5 min
T + 3 min
T + 3.5 min
T + 4 min
T + 7 min
T + 8 min
T + 10 min
BACKSCATTER AMPLITUDE
2000

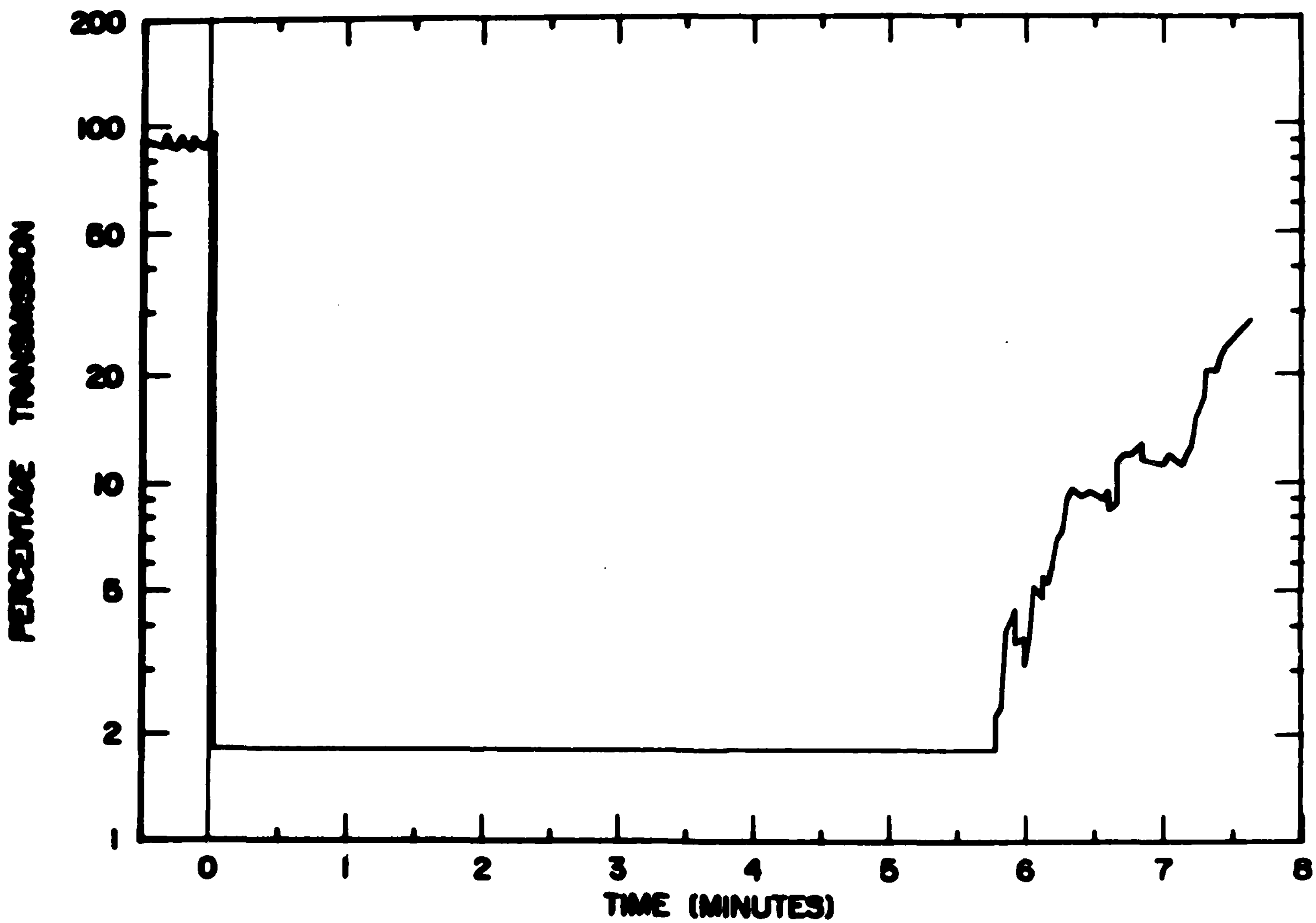


Figure 24. Event C-1 10.6μm transmission.

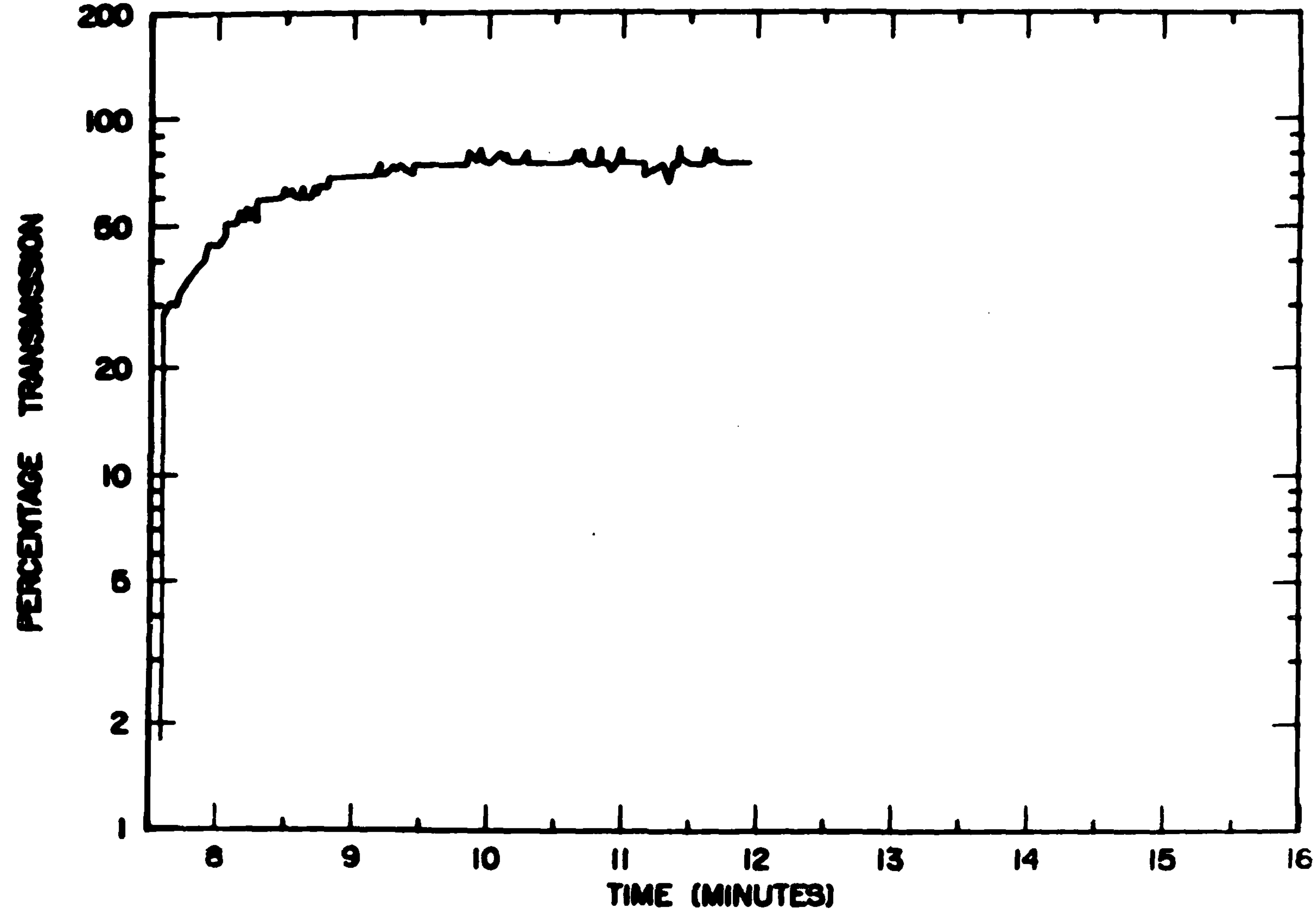

200
100
60
20
10
5
2
1
PERCENTAGE TRANSMISSION
8
9
10
11
12
13
14
15
16
TIME (MINUTES)

Fig.r 25 (cont

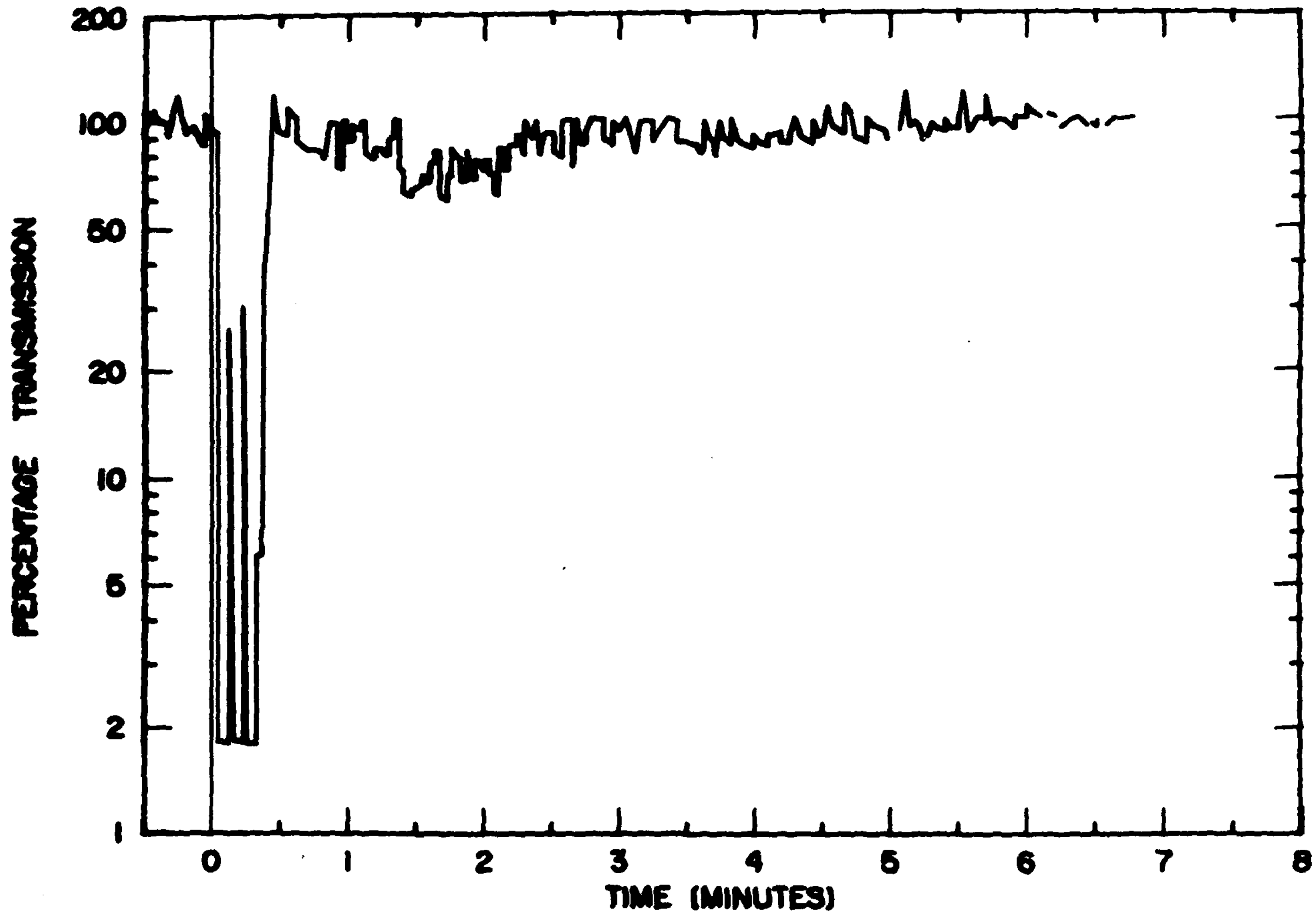


Figure 26. Event D-1 10.6μm transmission.

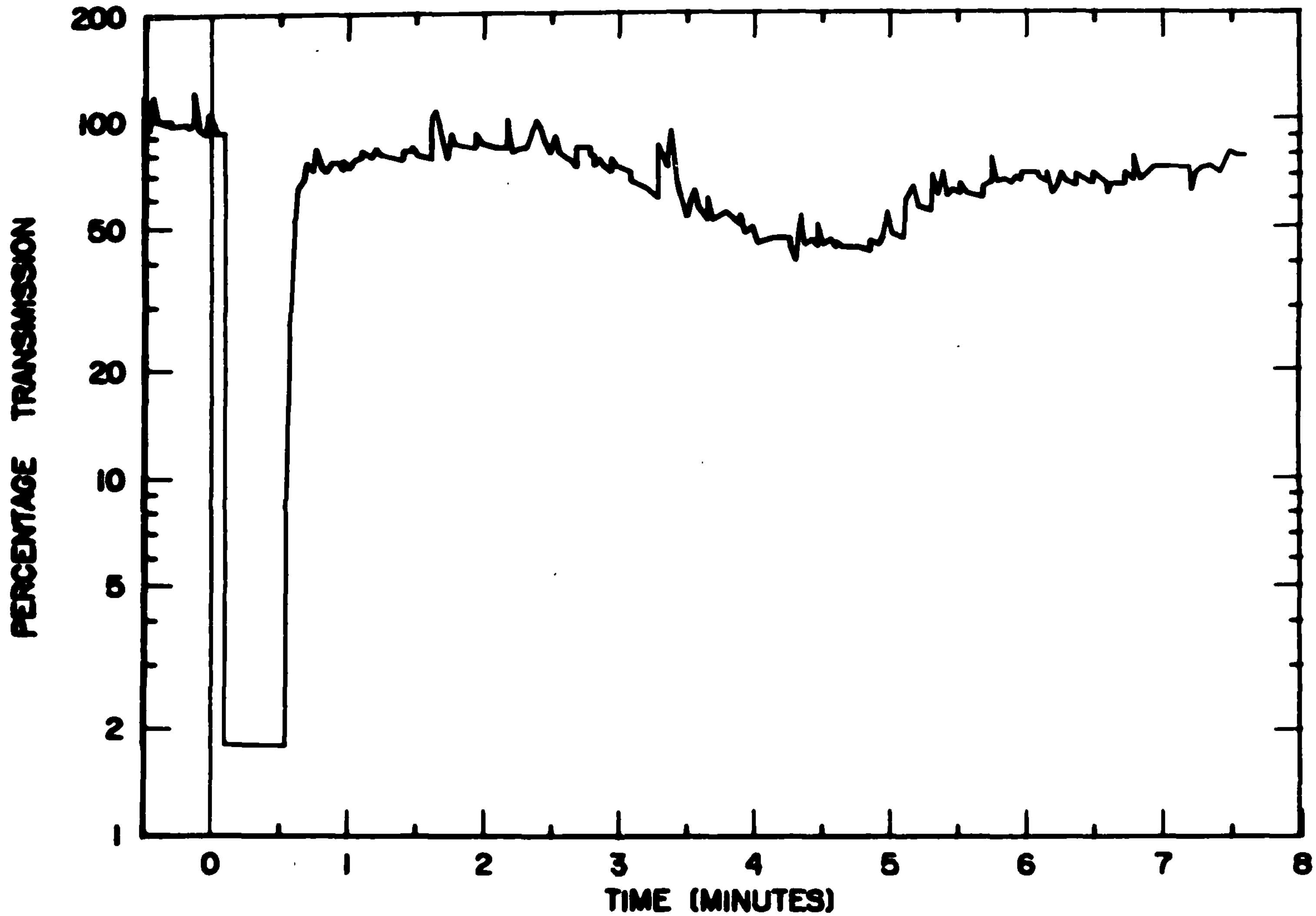


Figure 27. Event D-2 10.6μm transmission.

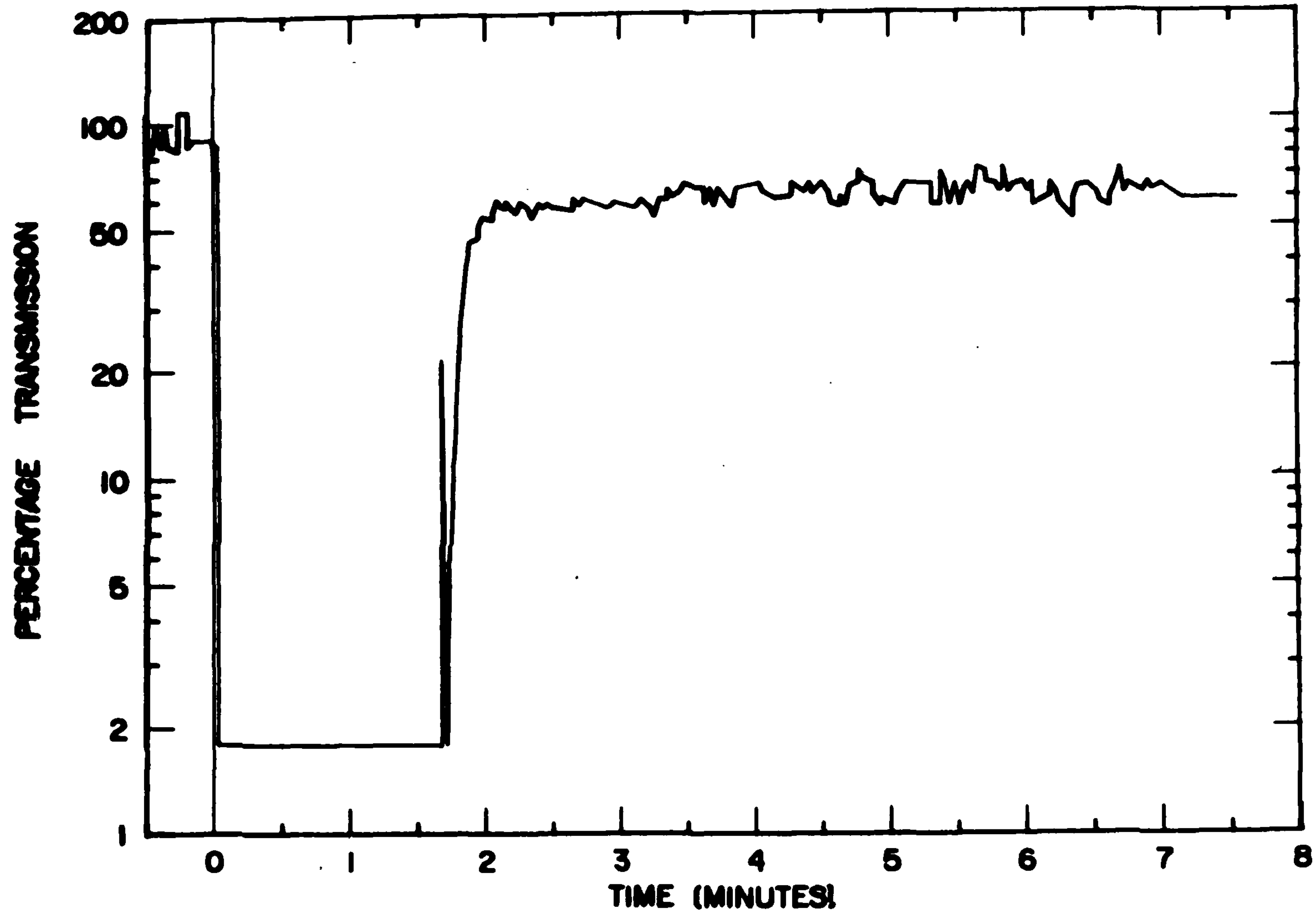


Figure 28. Event D-3 10.6μm transmission.

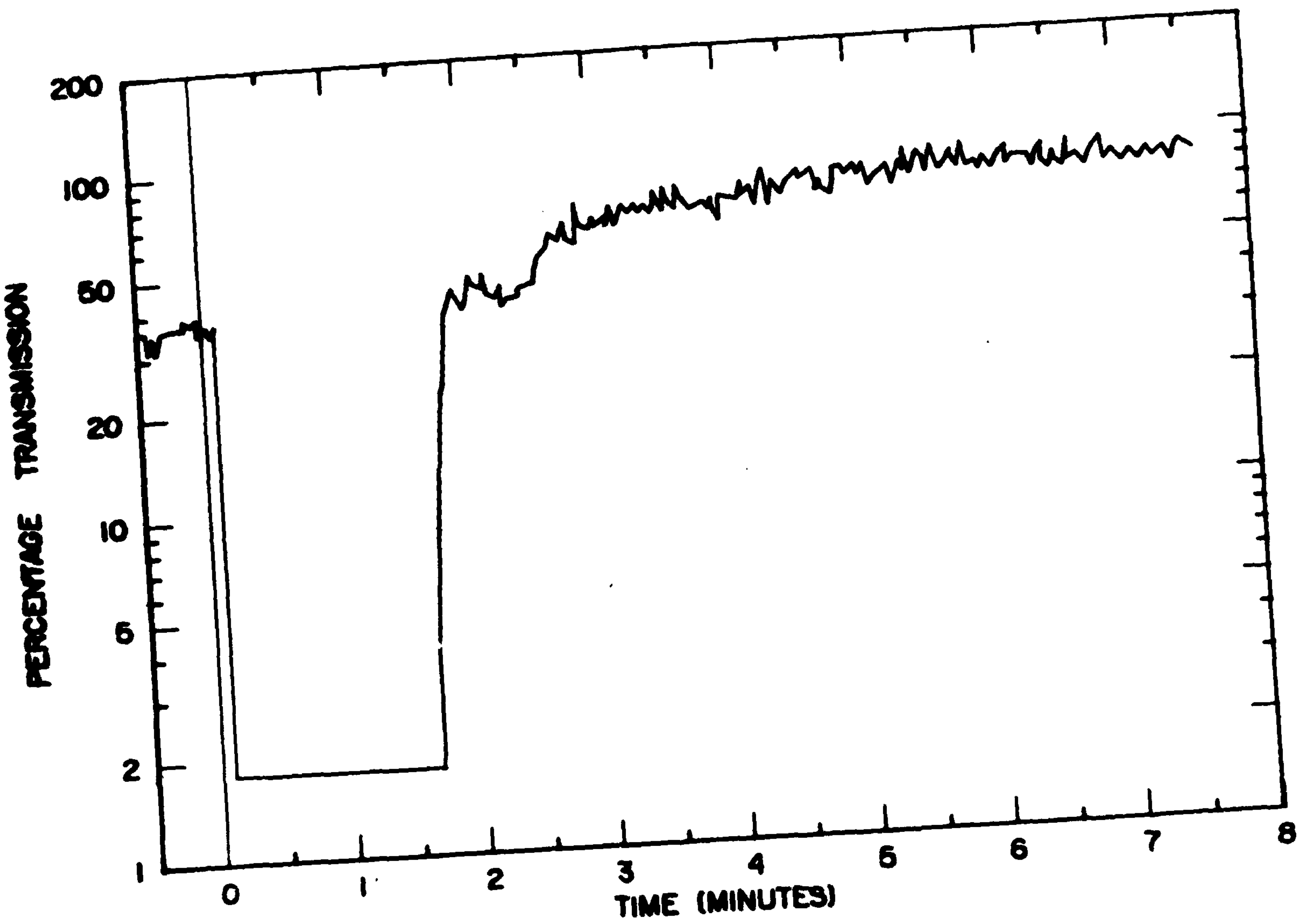
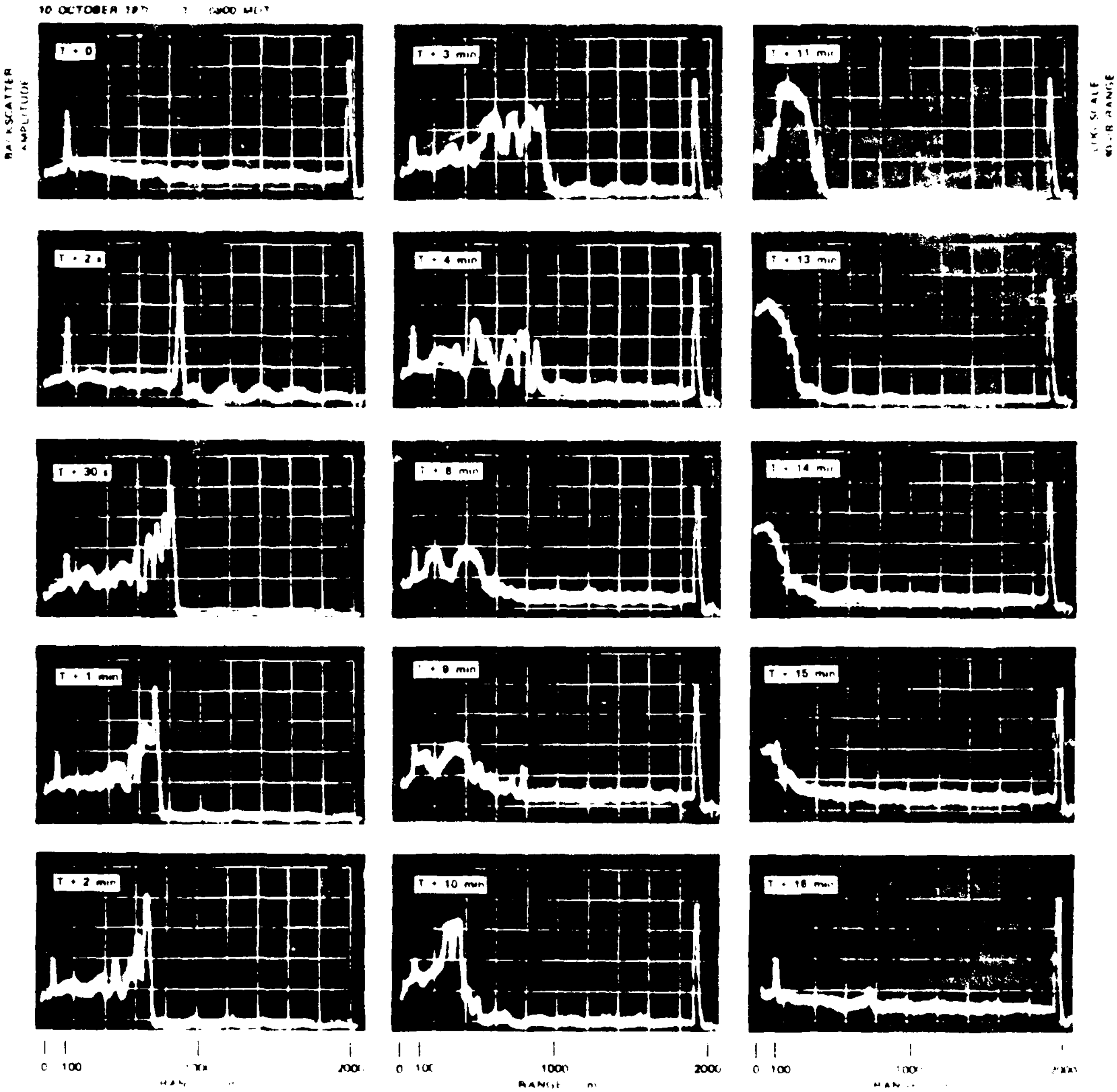


Figure 29. Event D-4 10.6μm transmission.


10 OCTOBER 197
BACKSCATTER AMPLITUDE
T + 0
T + 3 min
T + 11 min
T + 2 s
T + 4 min
T + 13 min
T + 30 s
T + 8 min
T + 14 min
T + 1 min
T + 9 min
T + 15 min
T + 2 min
T + 10 min
T + 16 min
0 100
2000
0 100 1000 2000
RANGE
0 100

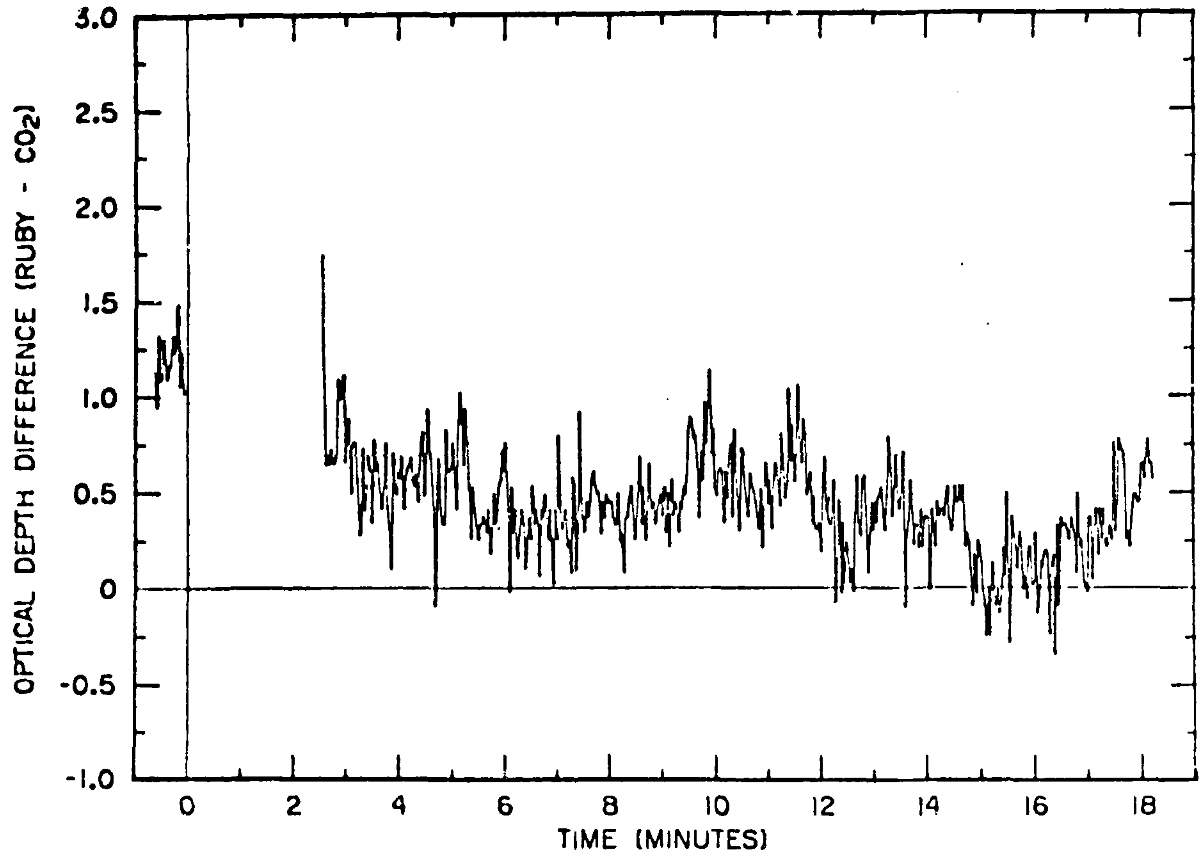


Figure 31. Difference between Ruby and CO_2 optical depths (C-[illegible]).

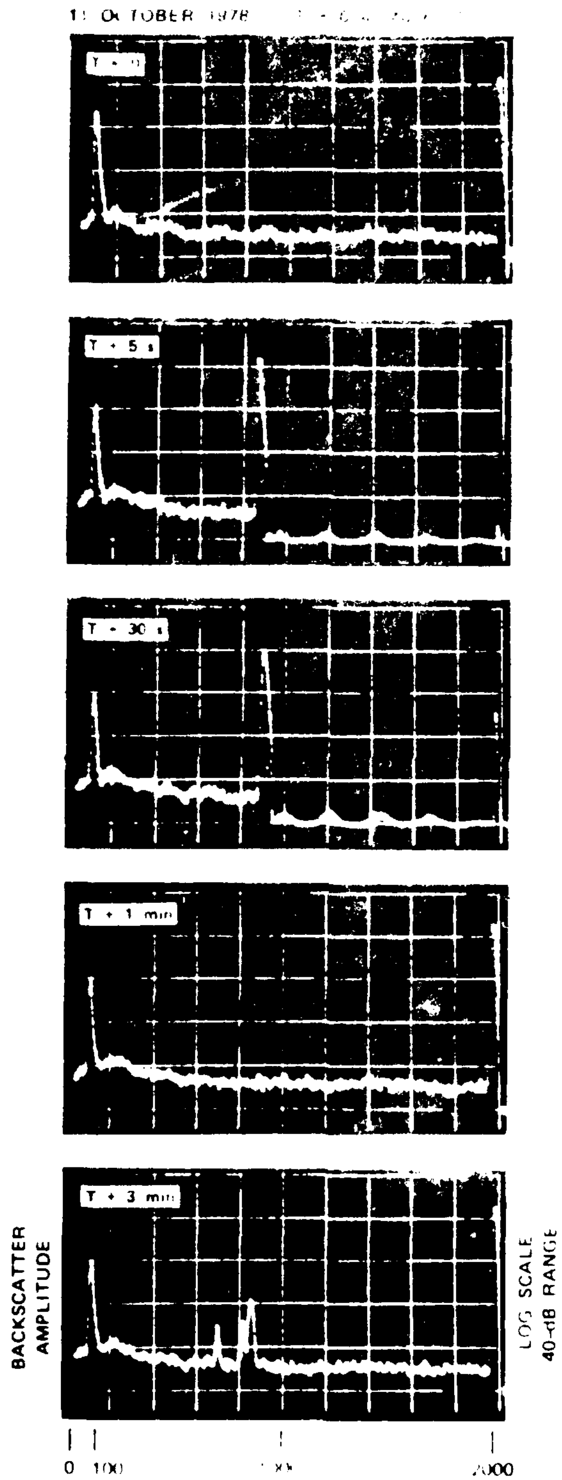


Figure 5. ter data.

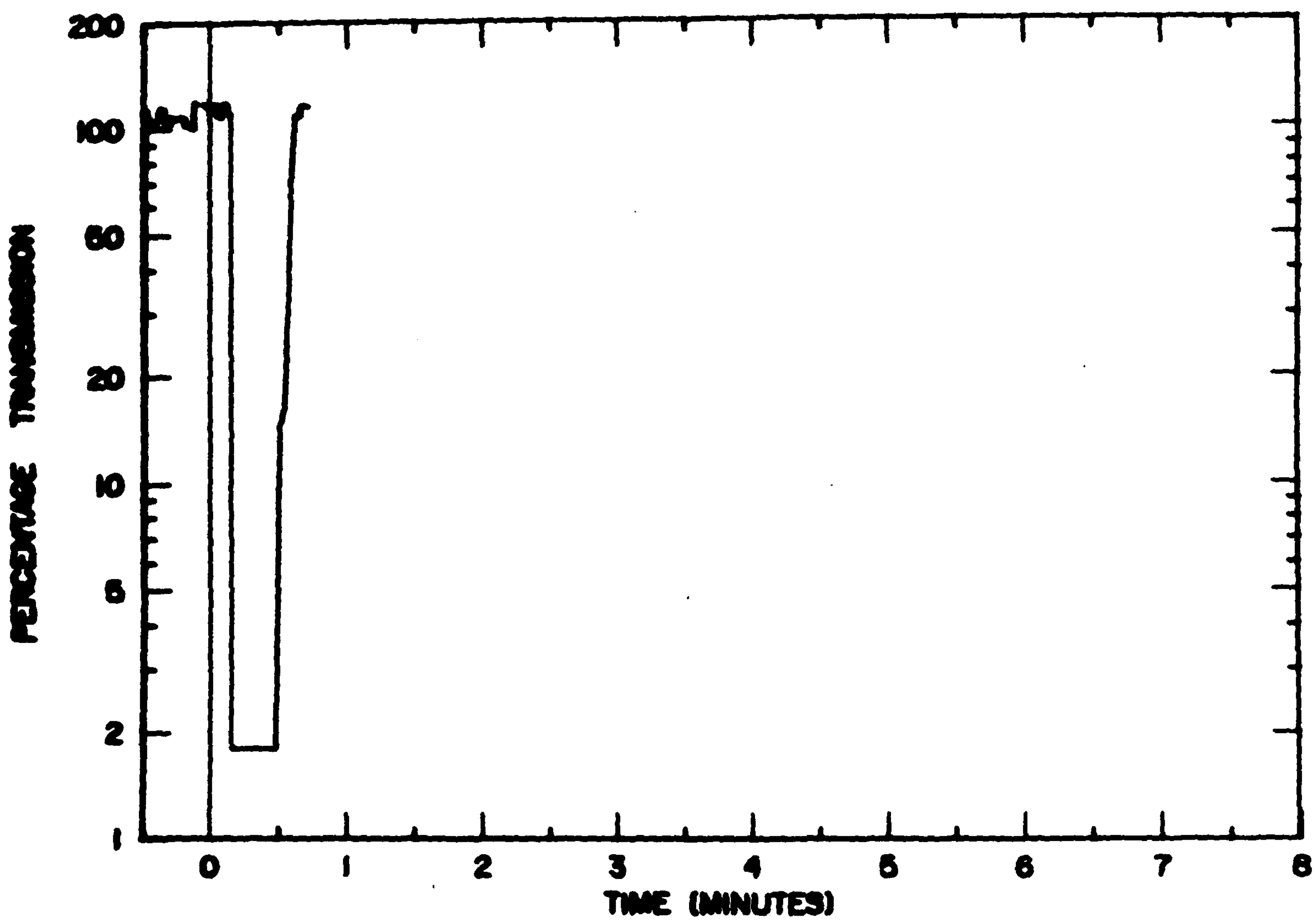


Figure 33. Event E-1 10.6μm transmission.

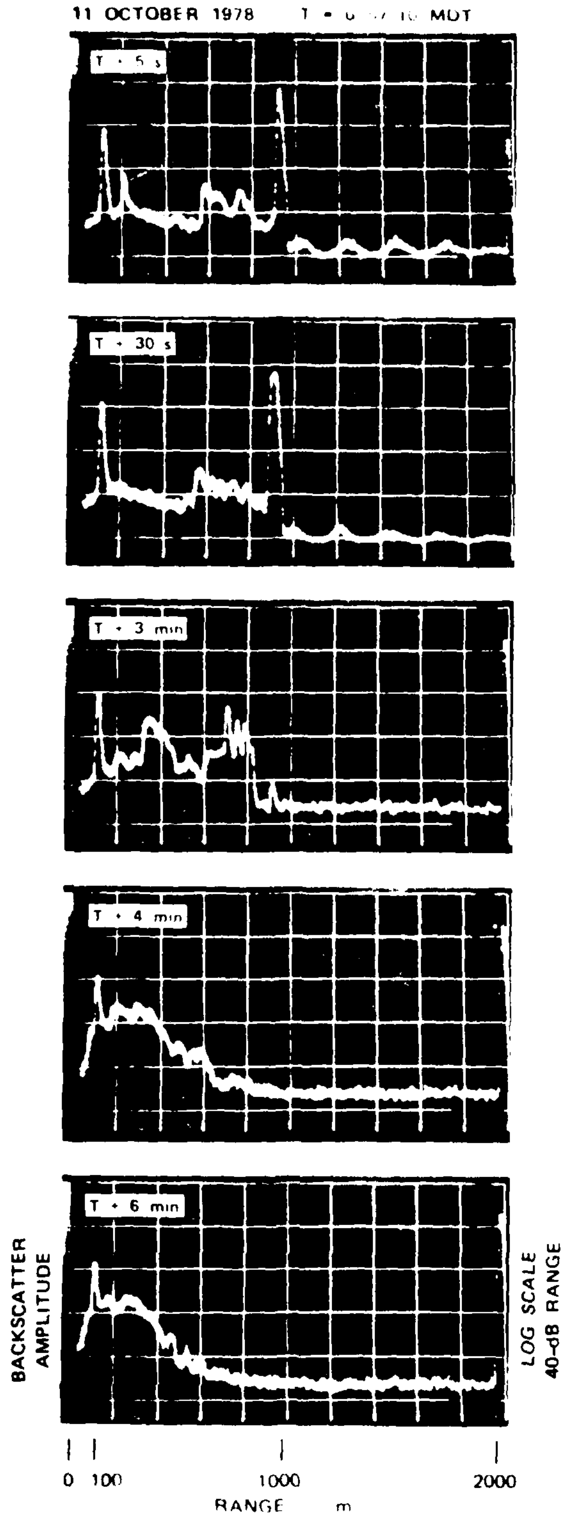


Figure 34. Event E-2 10.6 μm backscatter data.

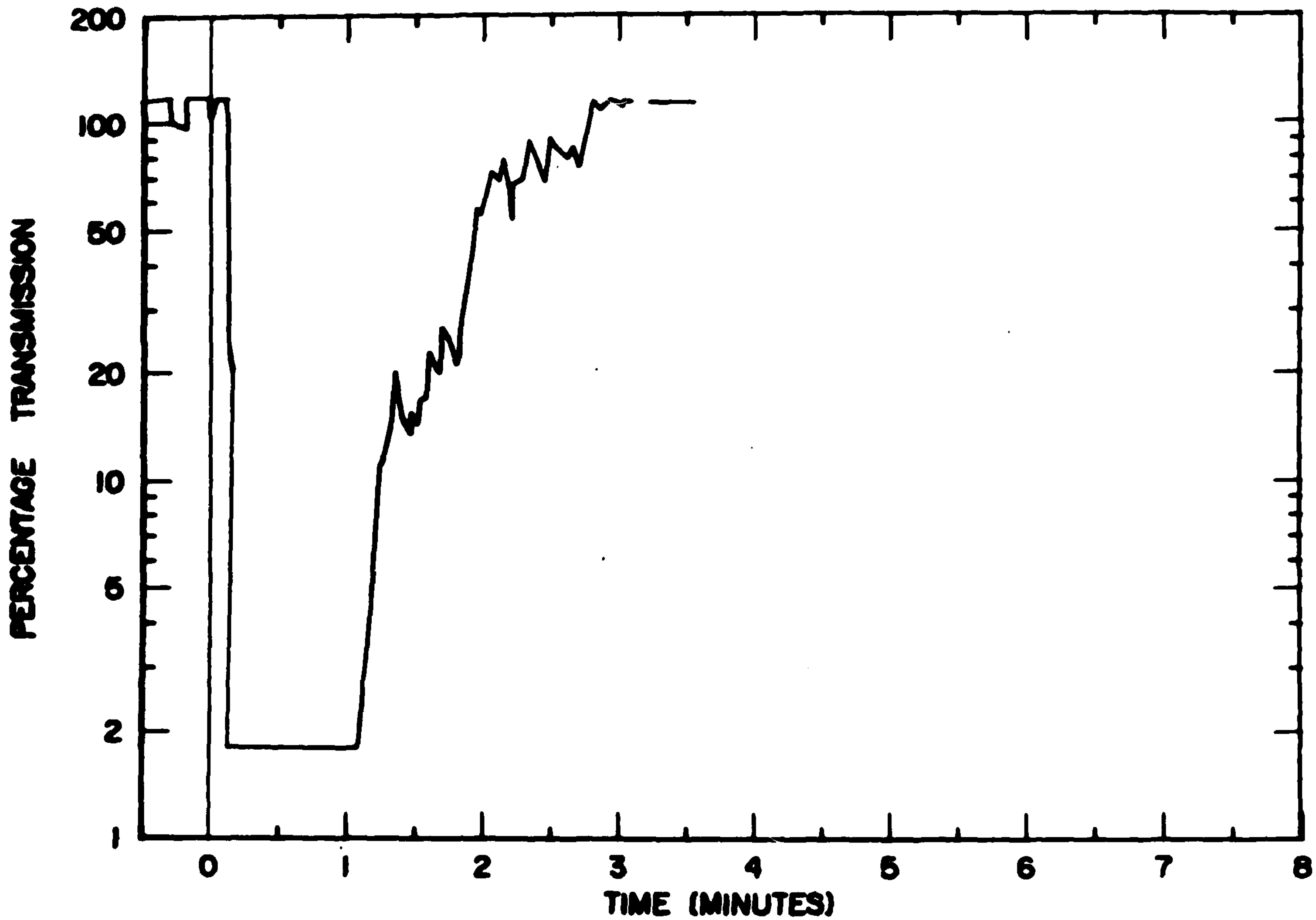


Figure 35. Event E-2 10.6μm transmission.

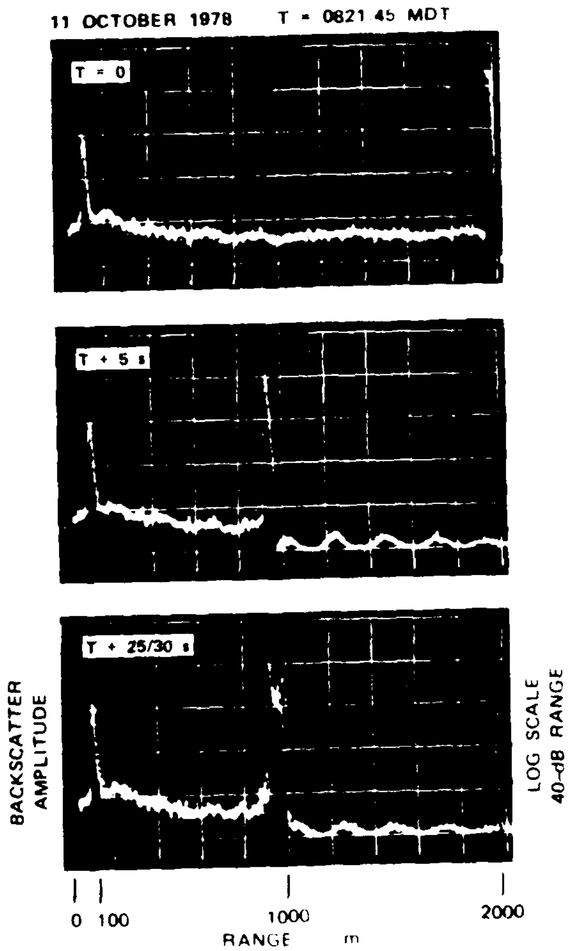


Figure 36. Event E-3 10.6-μm backscatter data.

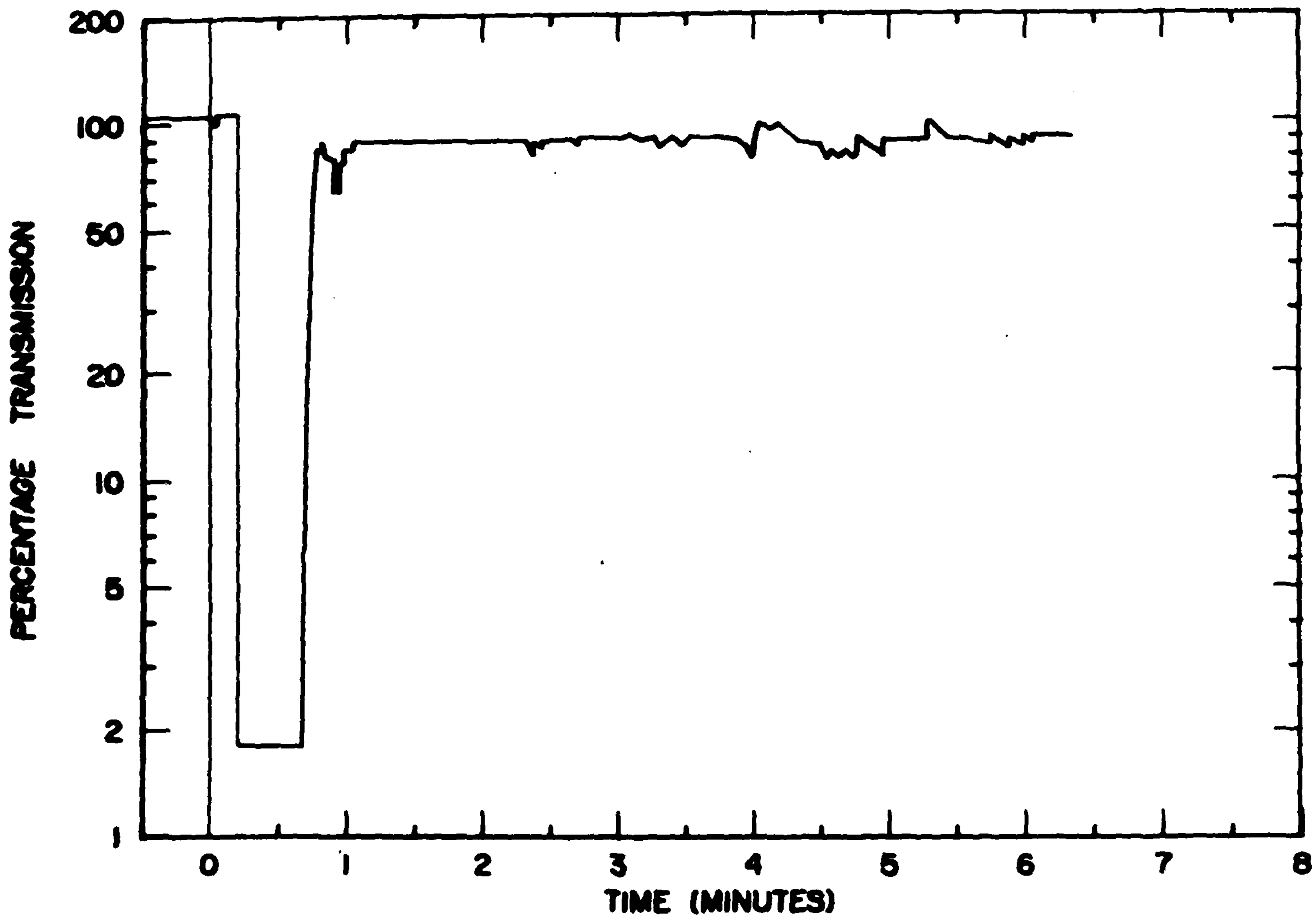


Figure 37. Event E-3 10.6μm transmission.

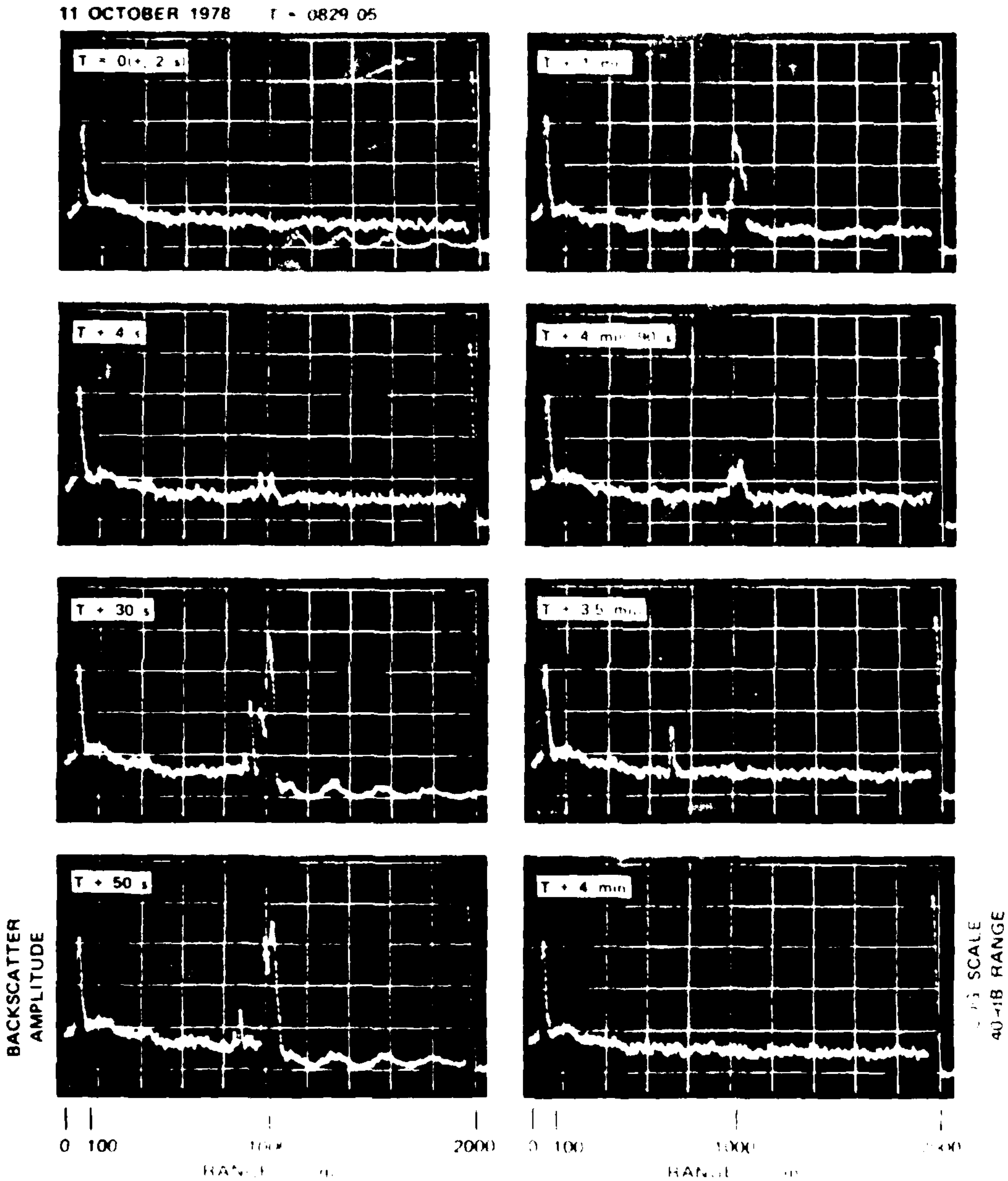


Figure [illegible] Event E-5 10.6 [illegible] backscatter data.

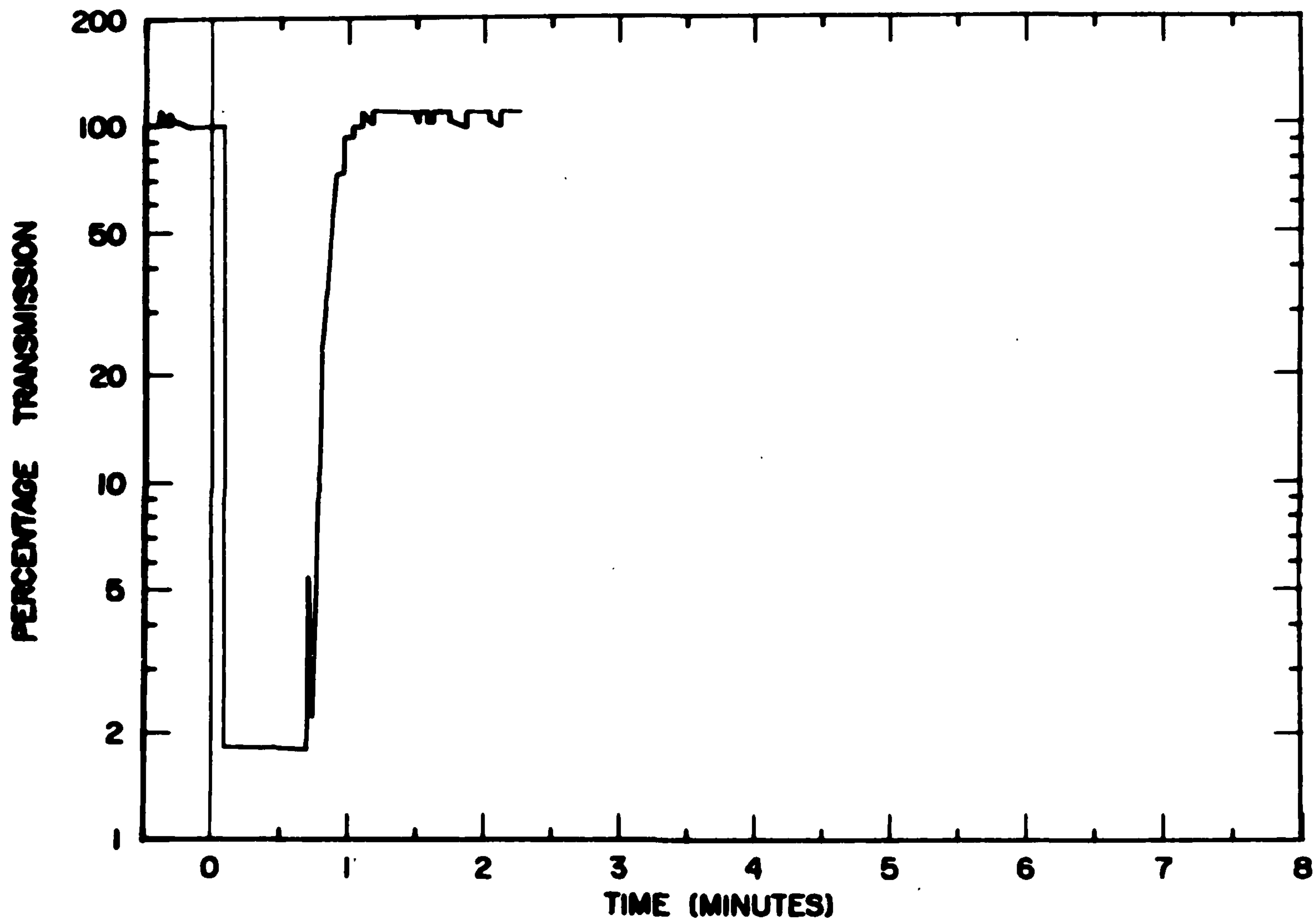


Figure 39. Event E-4 10.6μm transmission.

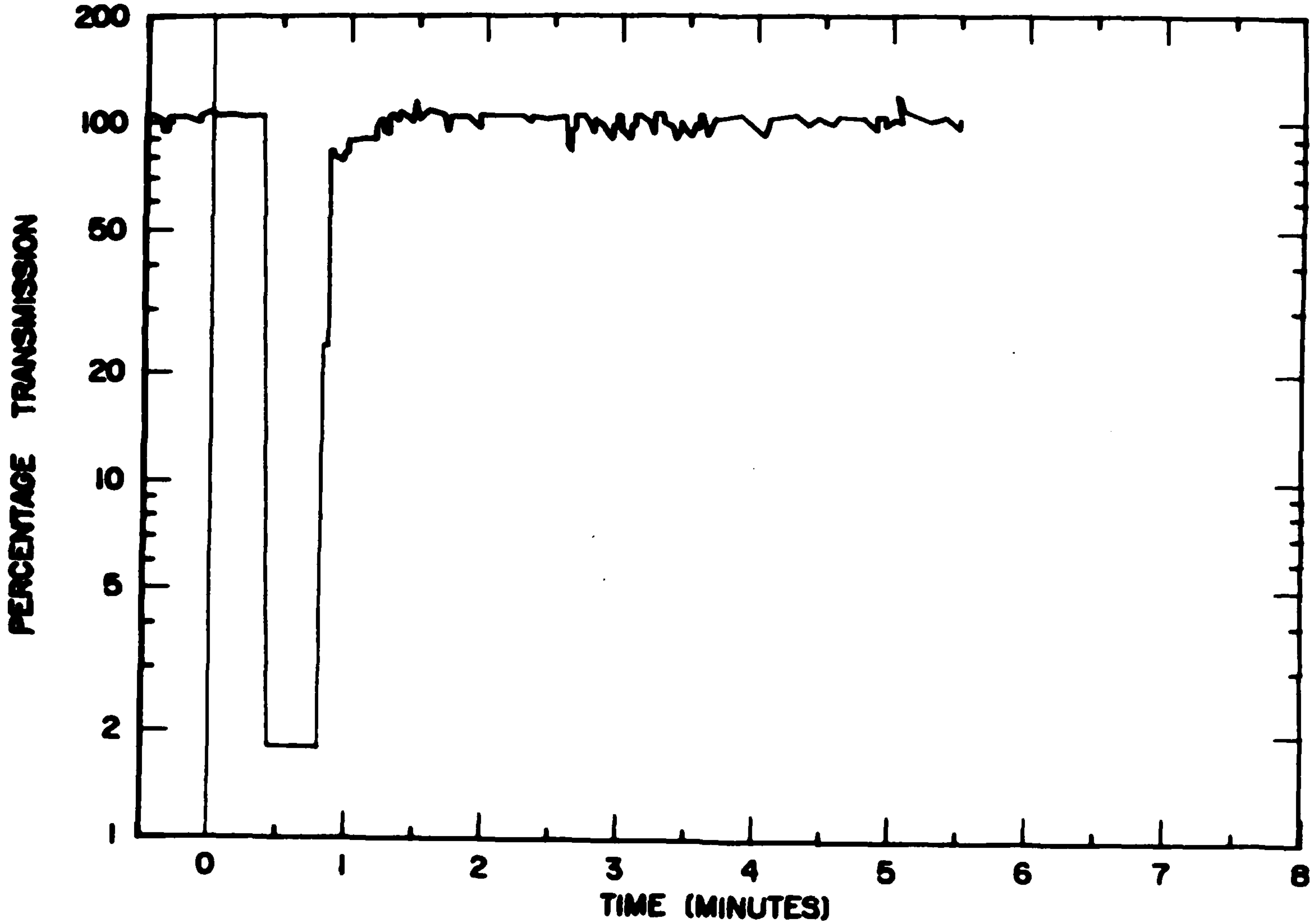


Figure 40. Event F-1 10.6μm transmission.

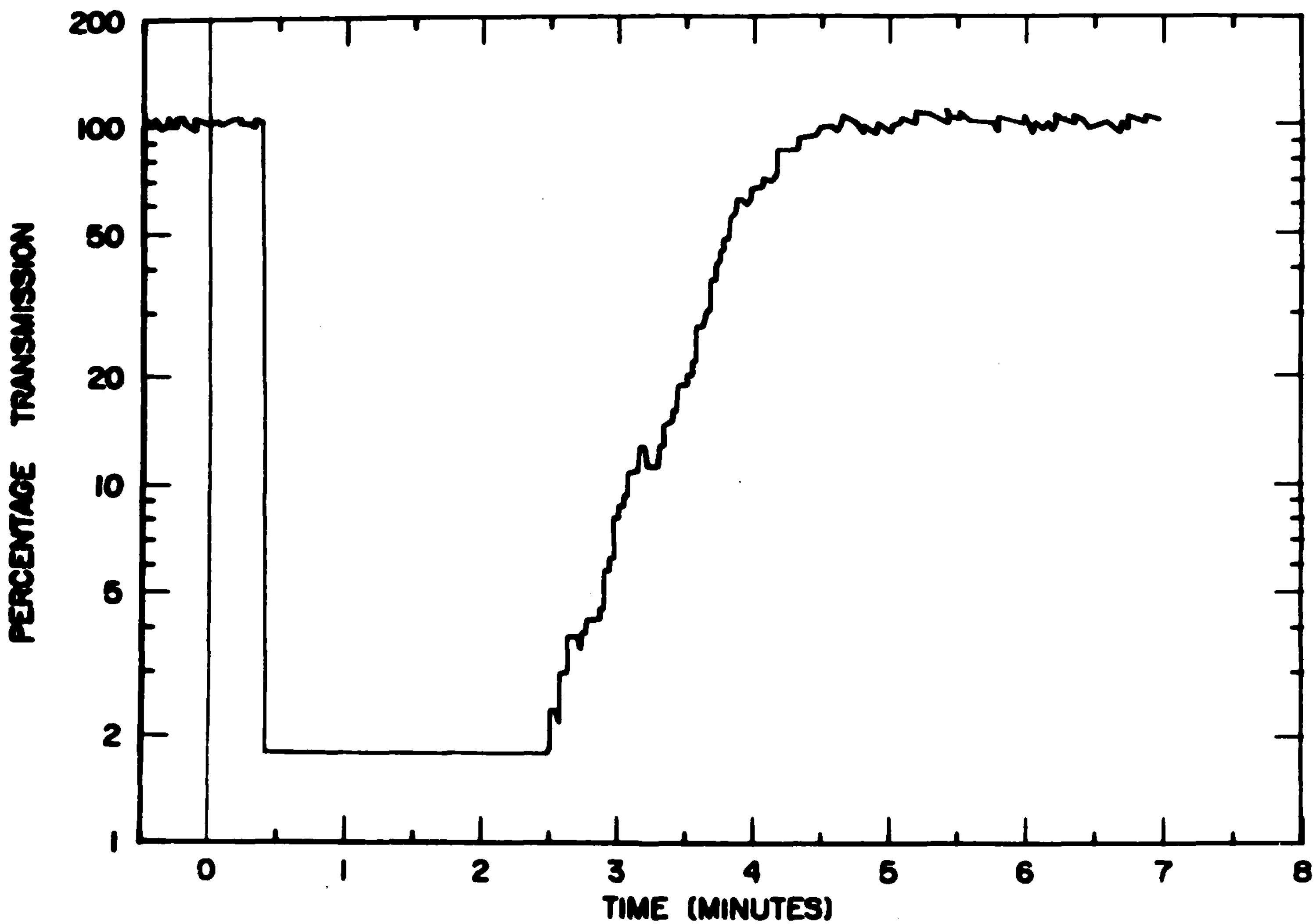


Figure 41. Event F-2 10.6μm transmission.

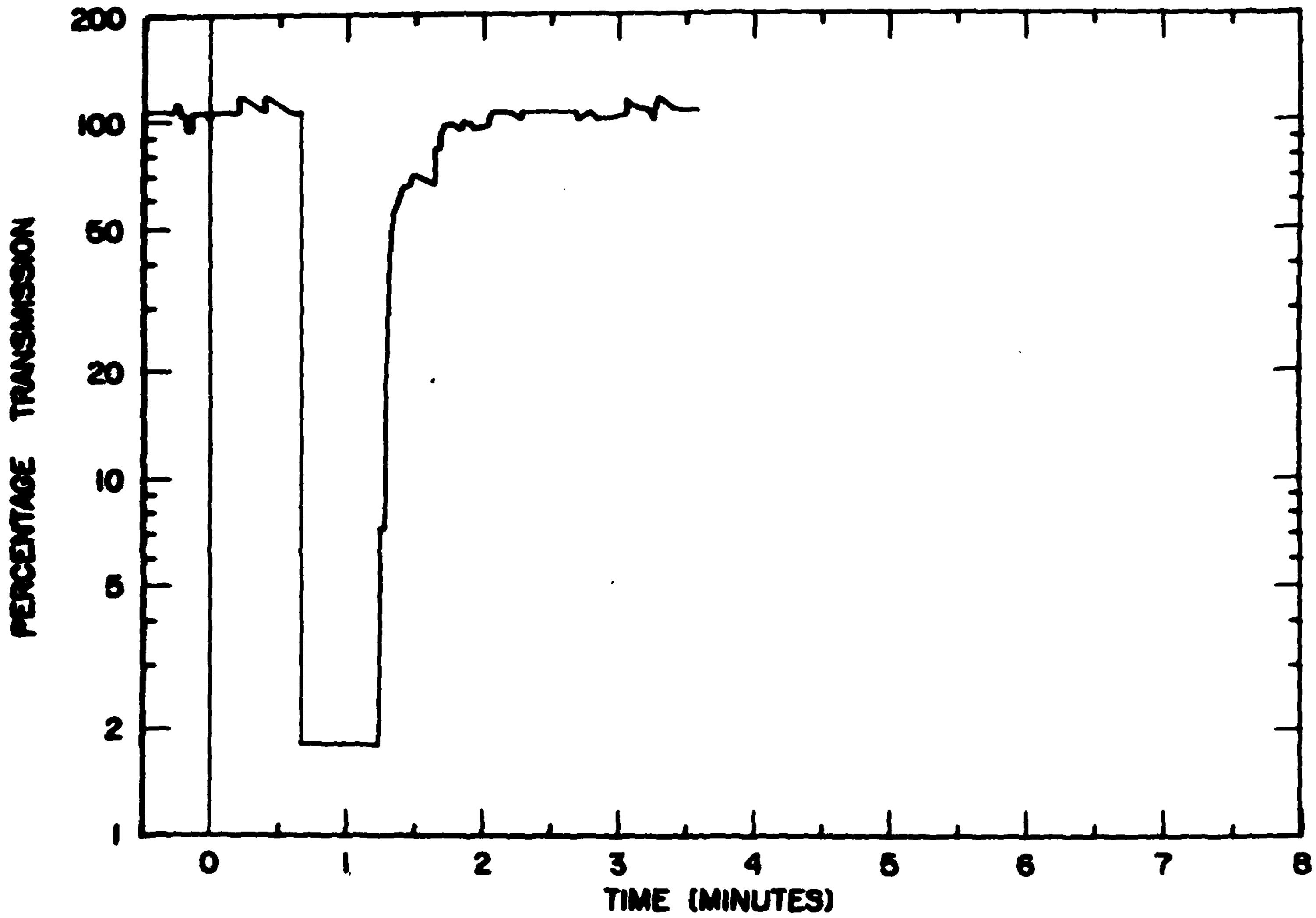
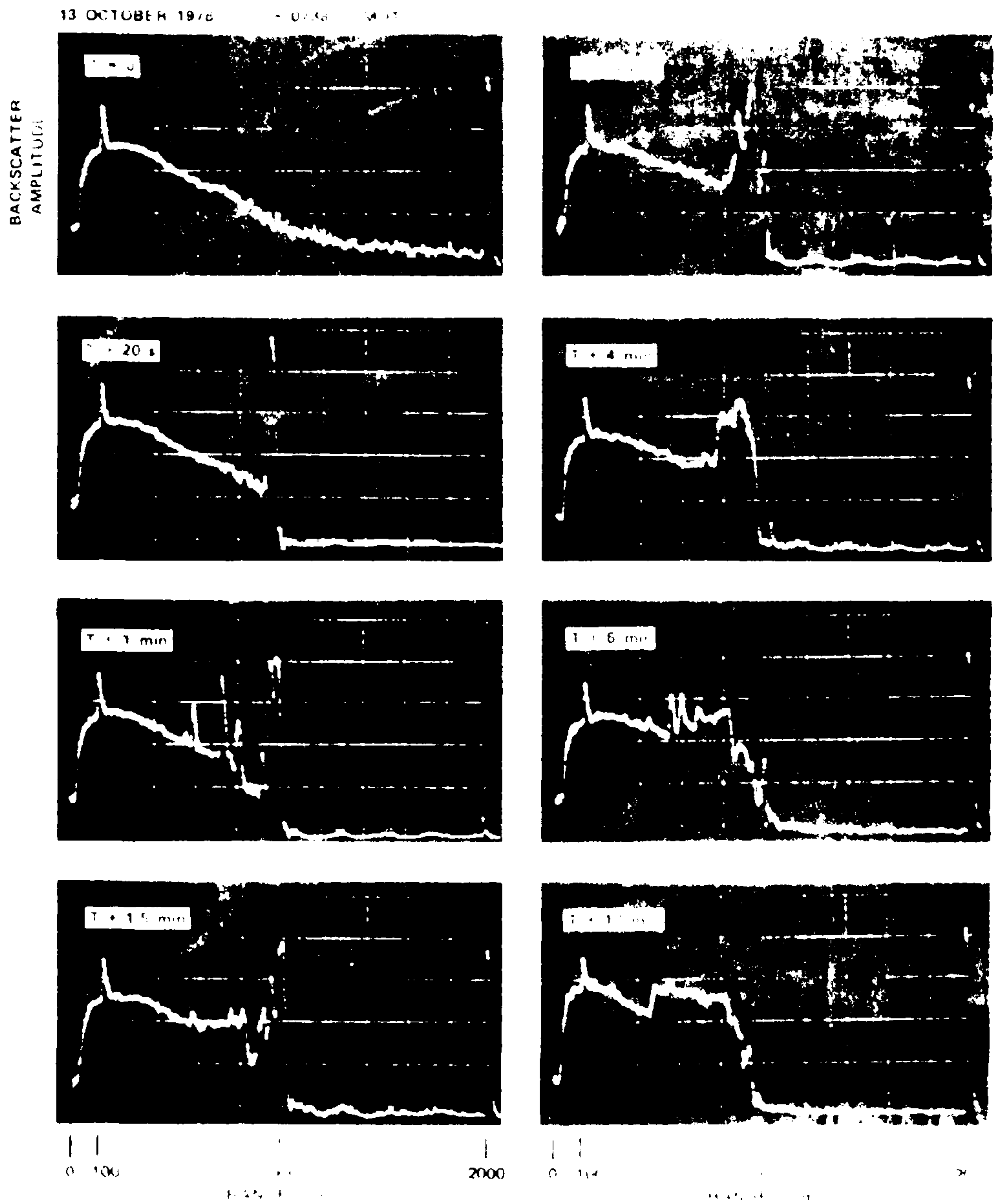


Figure 42. Event F-3 10.6μm transmission.


13 OCTOBER 197
BACKSCATTER
AMPLITUDE
20 s
T + 4 mi
T + 1 min
T + 6 mi
0
100
2000
0

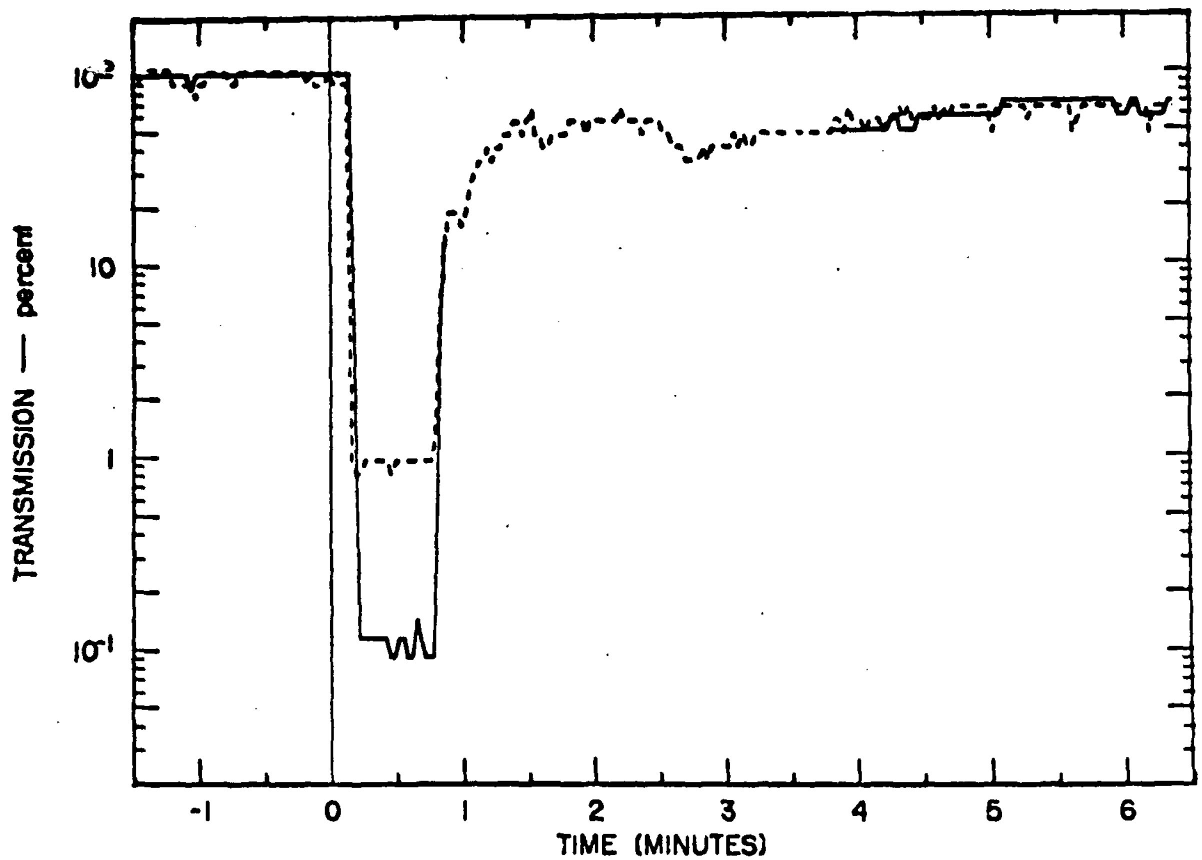


Figure 44. Transmission observed by the two-wavelength lidar system (F-5).

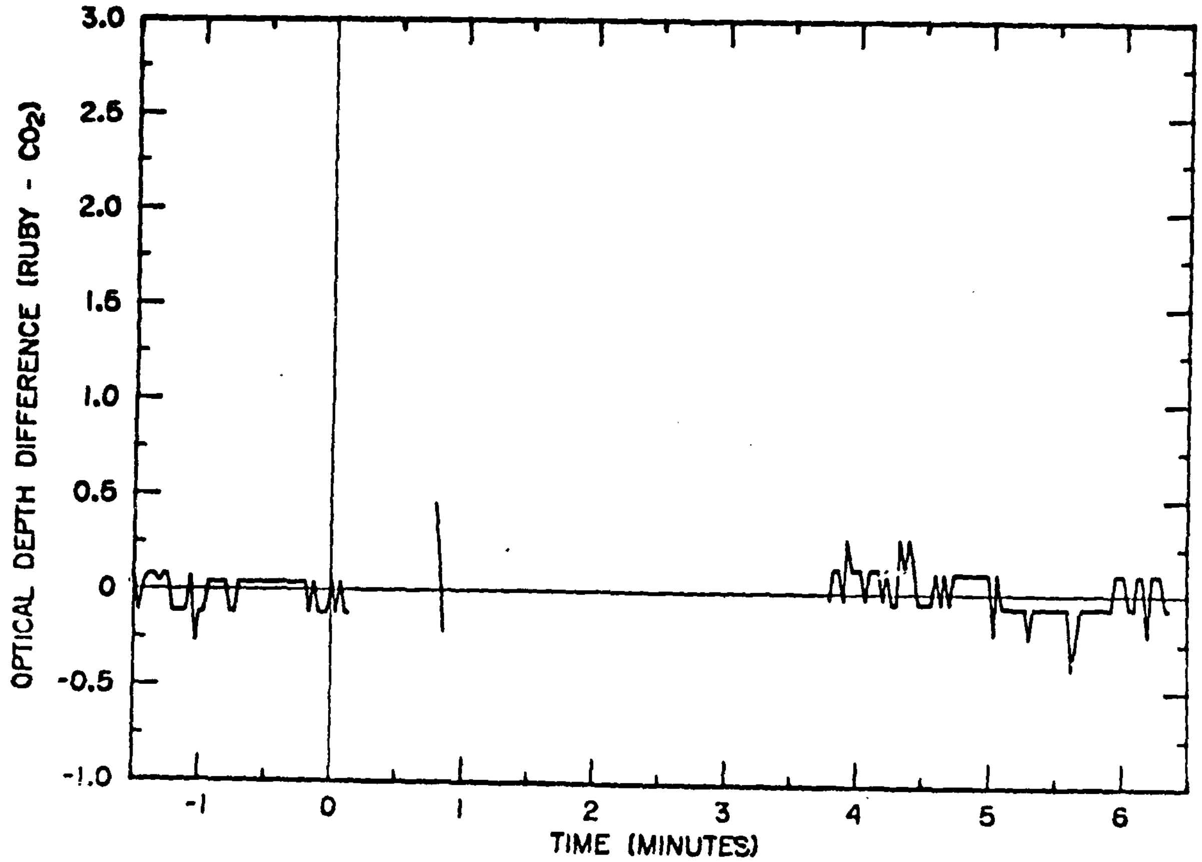


Figure 45. Difference between Ruby and CO_2 optical depths (V-5).

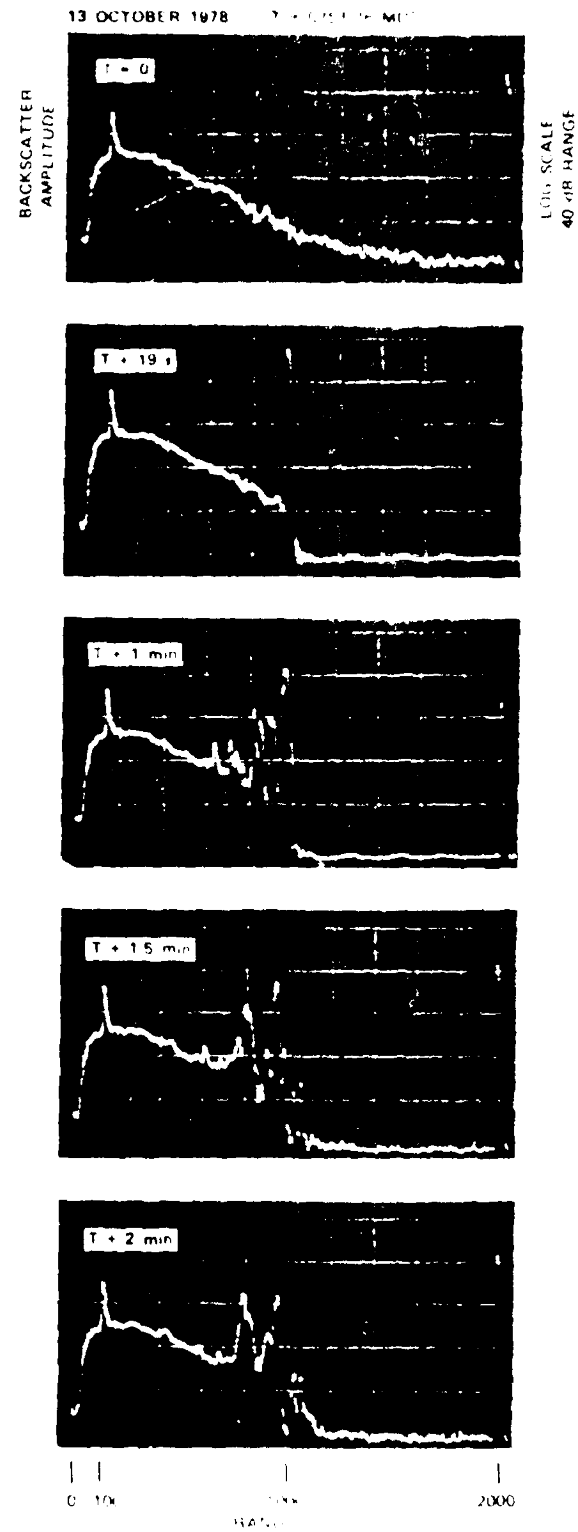


Figure 56. [illegible] atter data.

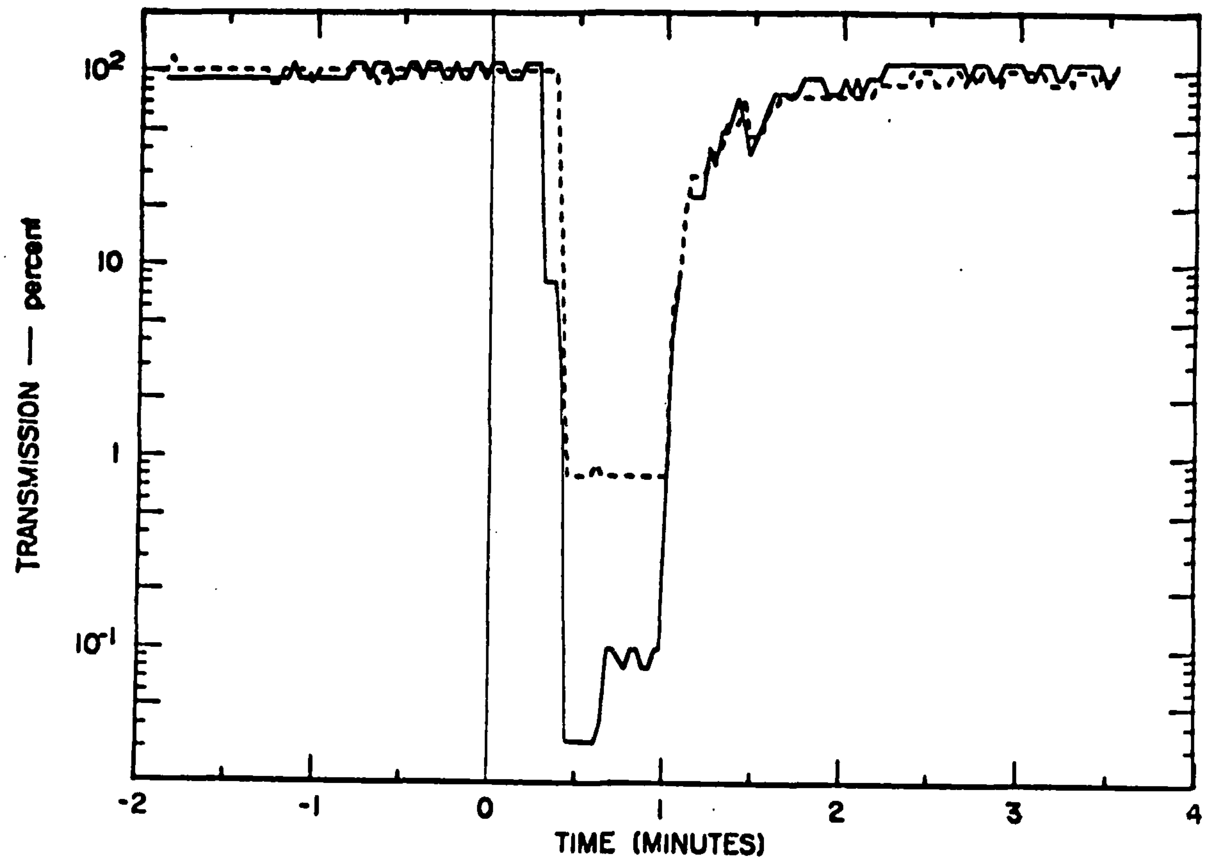


Figure 47. Transmission observed by the two-wavelength lidar system (F-6).

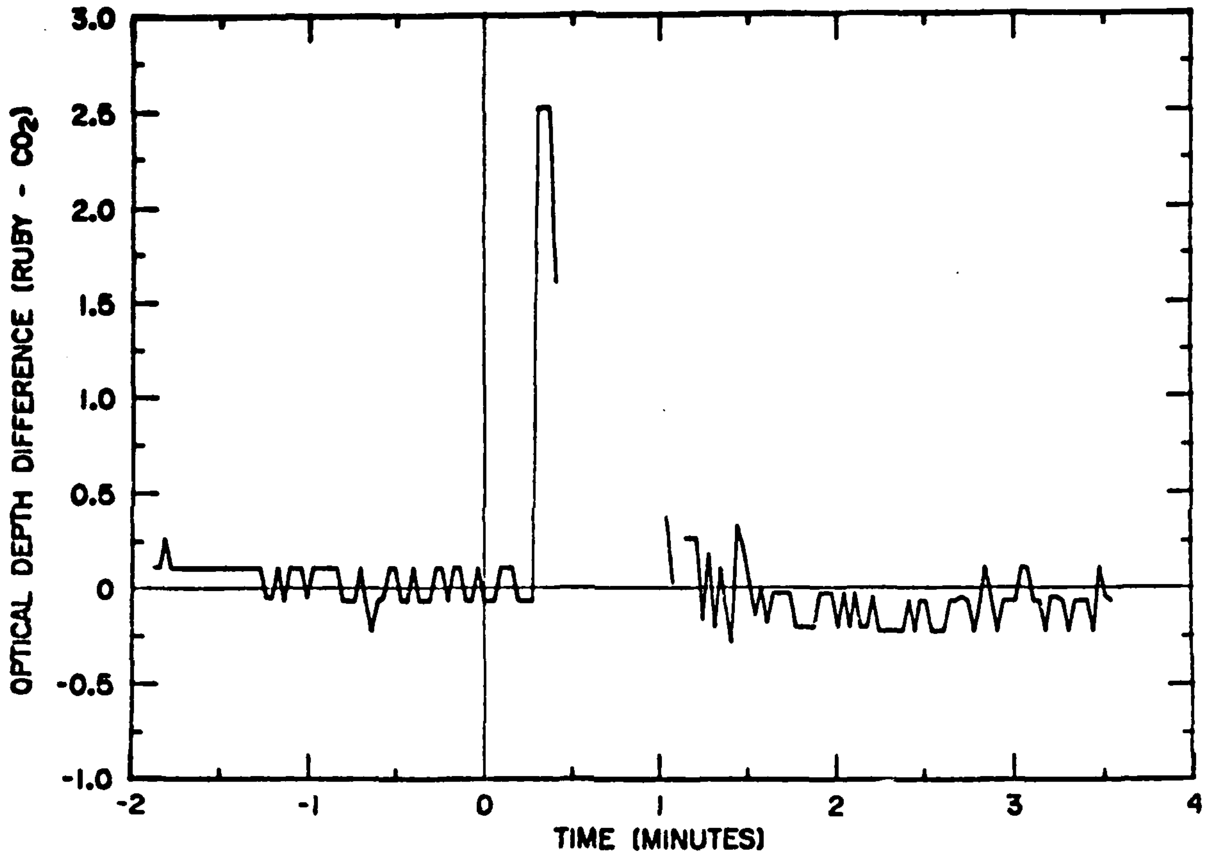
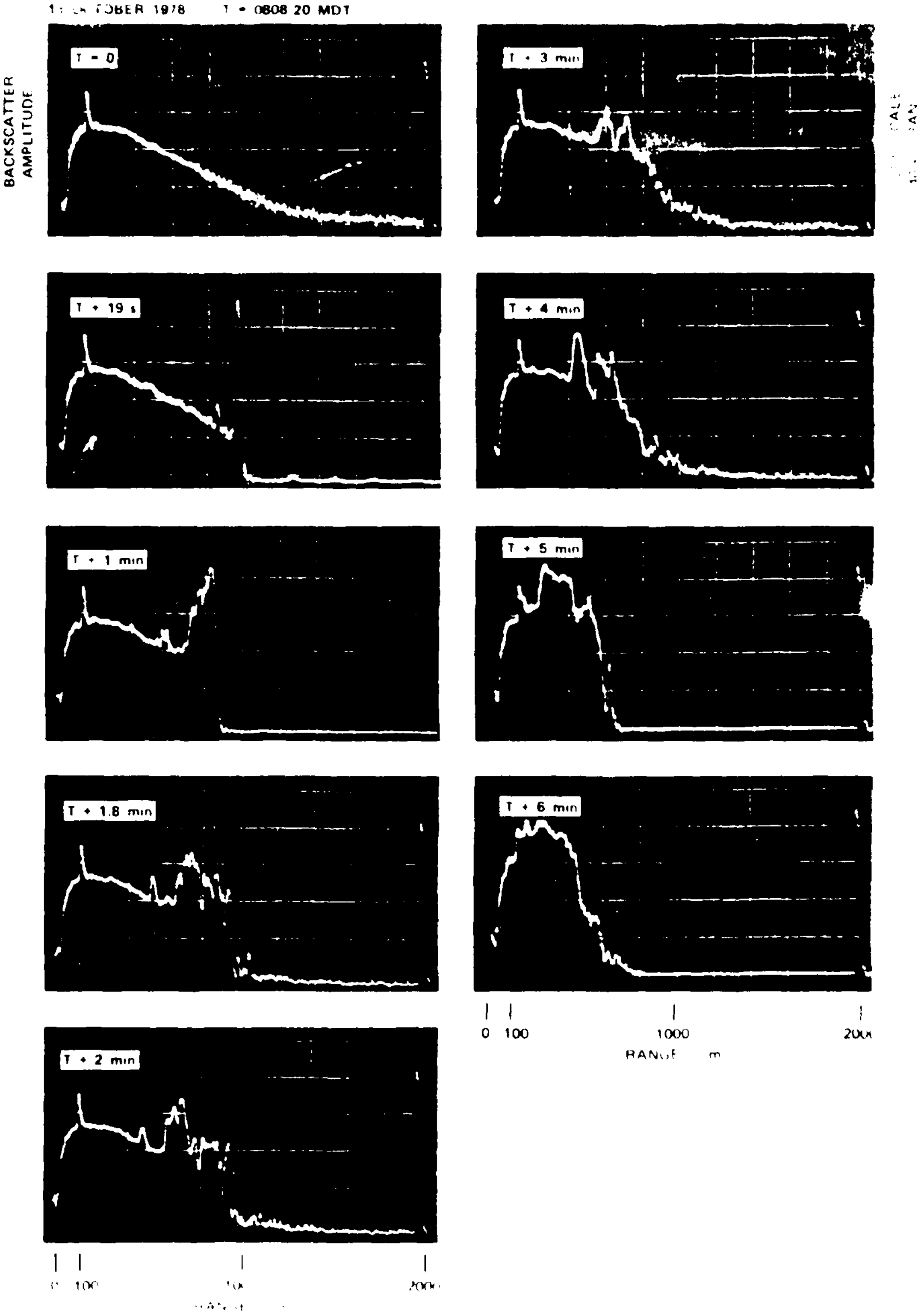


Figure 48. Difference between Ruby and CO_2 optical depths (F-6).


T = 0808 20 MDT
BACKSCATTER AMPLITUDE
T = 0
T + 19 s
T + 1 min
T + 1.8 min
T + 2 min
T + 3 min
T + 4 min
T + 5 min
T + 6 min
0
100
1000
RANGE m

[illegible] 10.6μm [illegible]

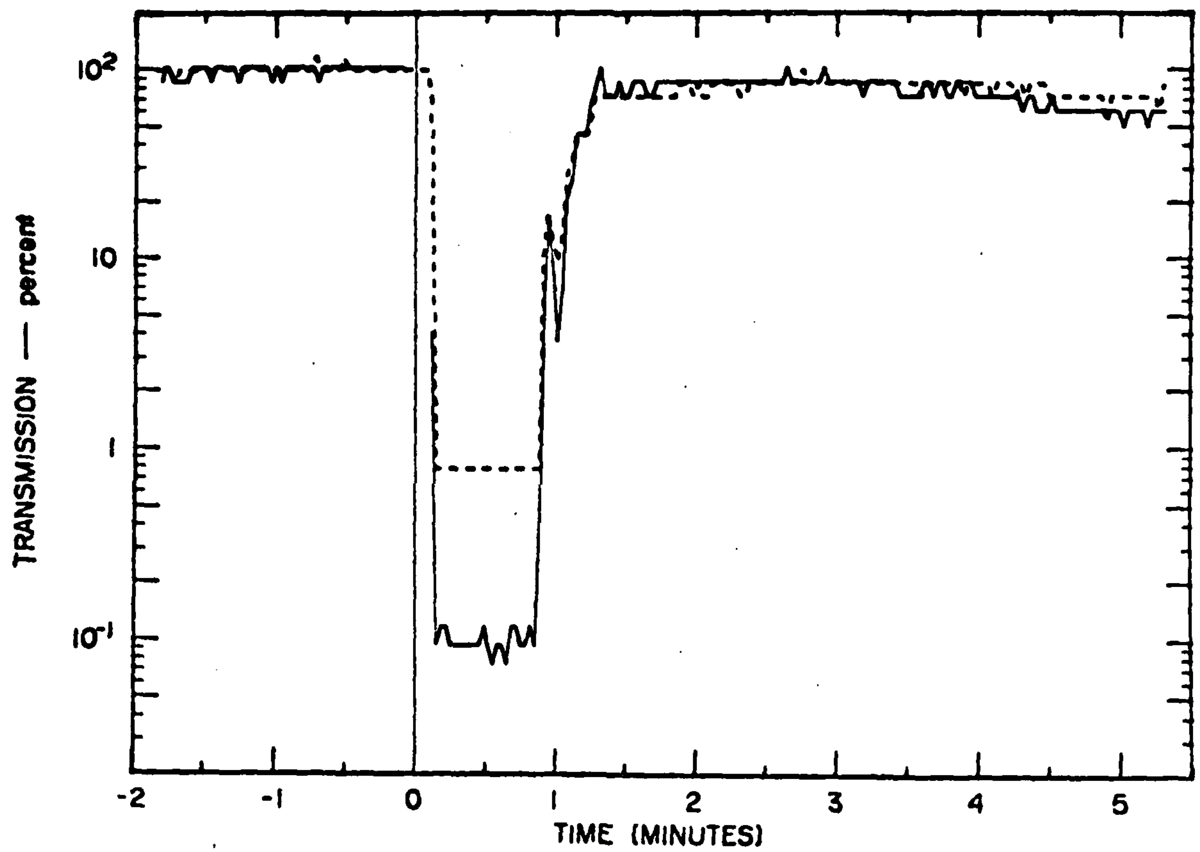


Figure 50. Transmission observed by the two-wavelength lidar system (F-7).

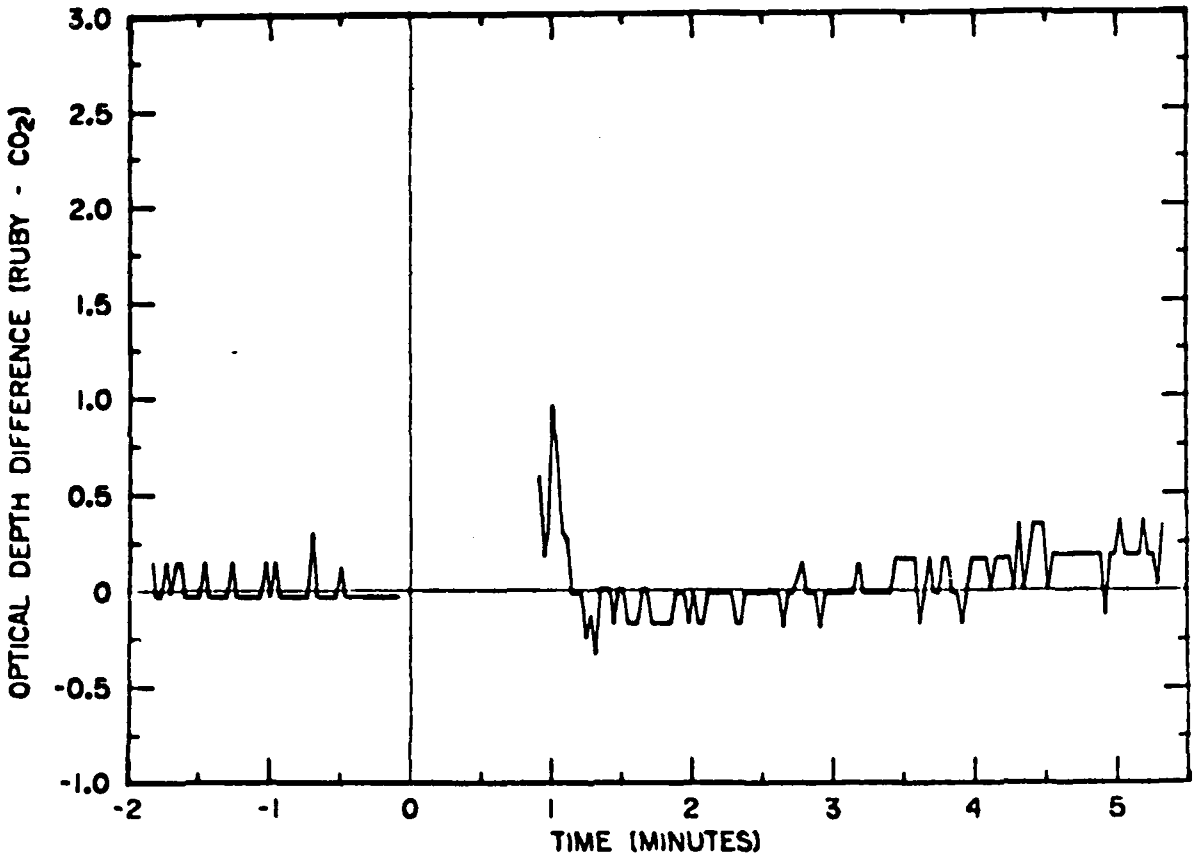
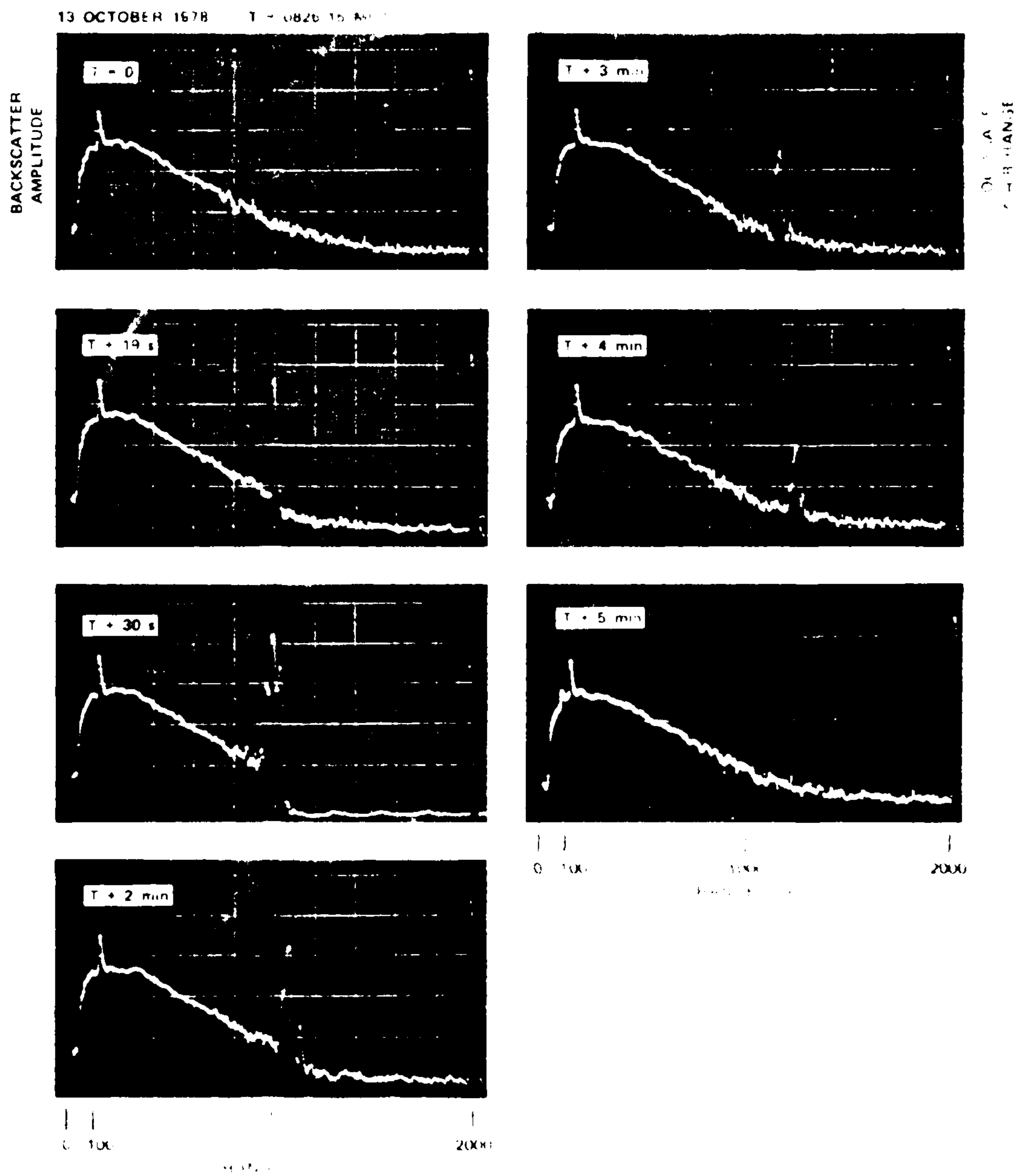


Figure 51. Difference between Ruby and CO_2 optical depths (F-7).


13 OCTOBER 1978
BACKSCATTER AMPLITUDE
T = 0
T + 3 min
T + 19 s
T + 4 min
T + 30 s
T + 5 min
T + 2 min
0
100
2000

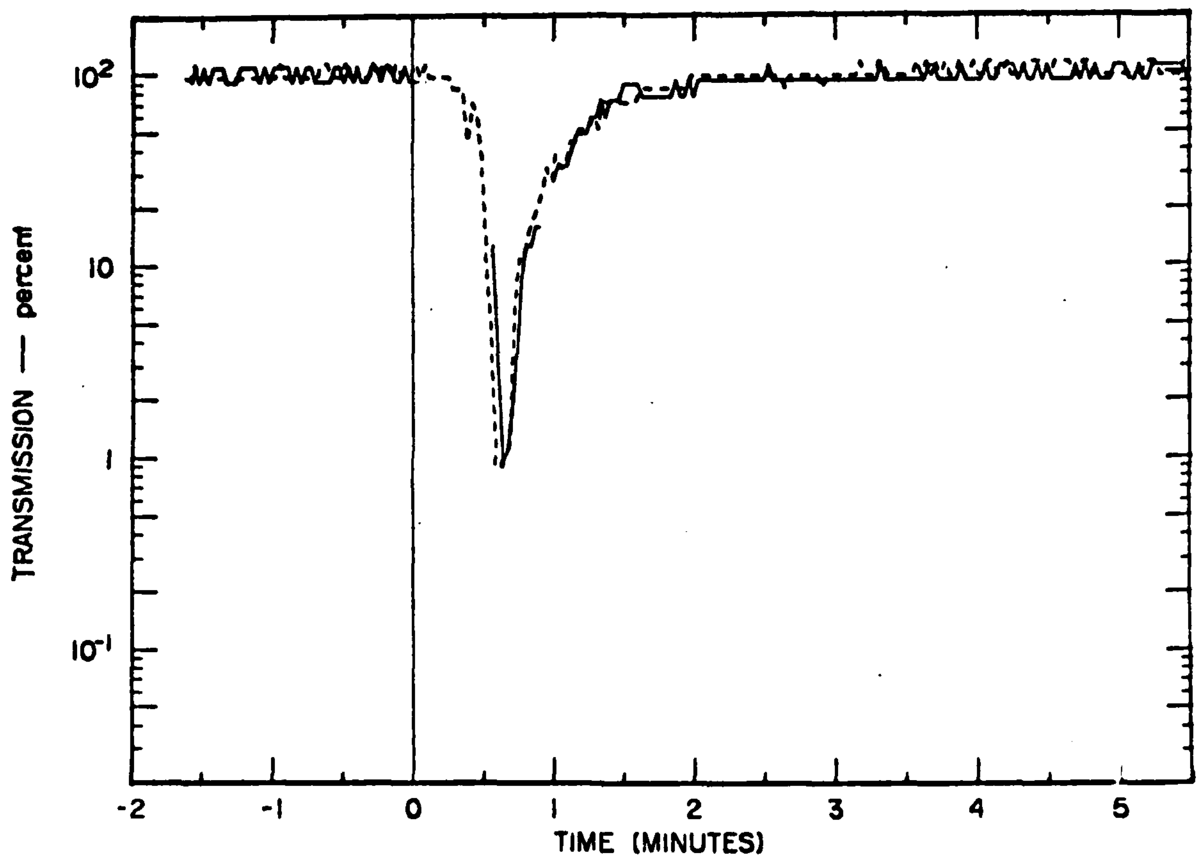


Figure 53. Transmission observed by the two-wavelength lidar syst[illegible] [illegible]-8).

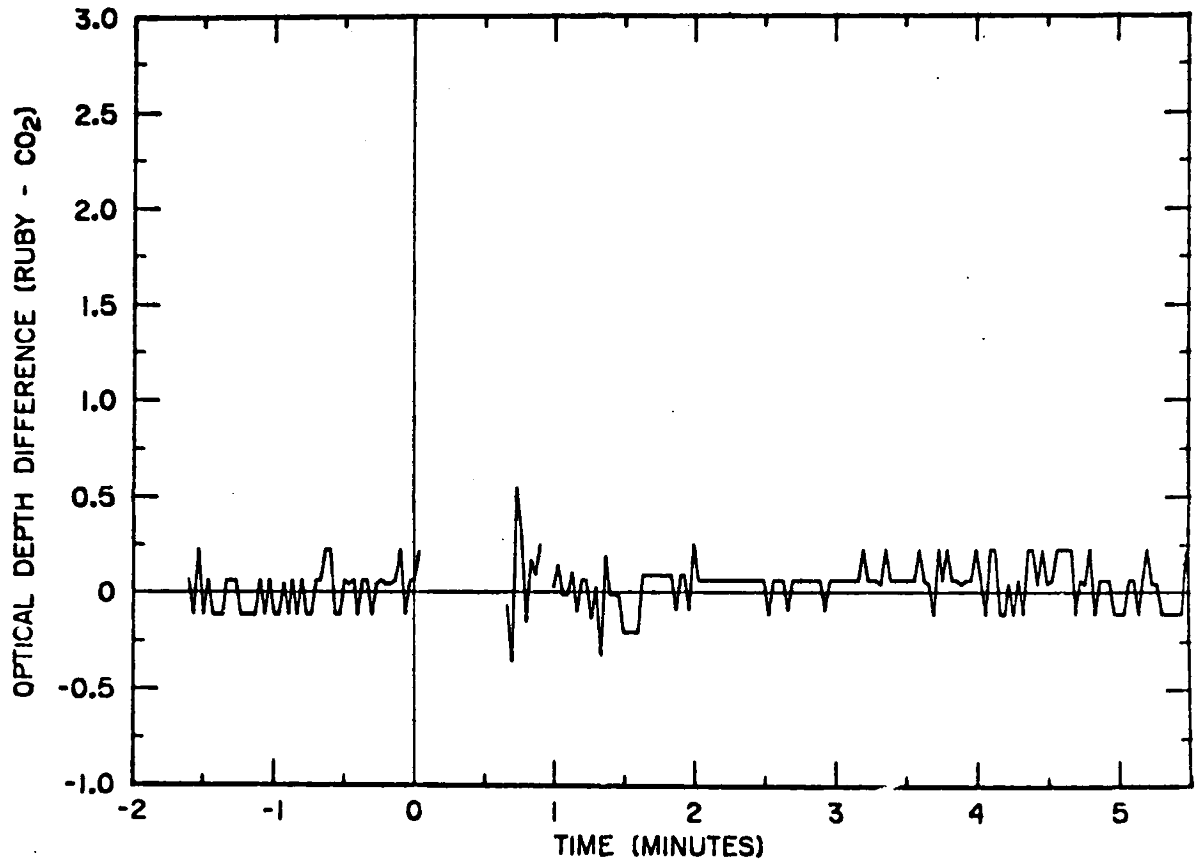
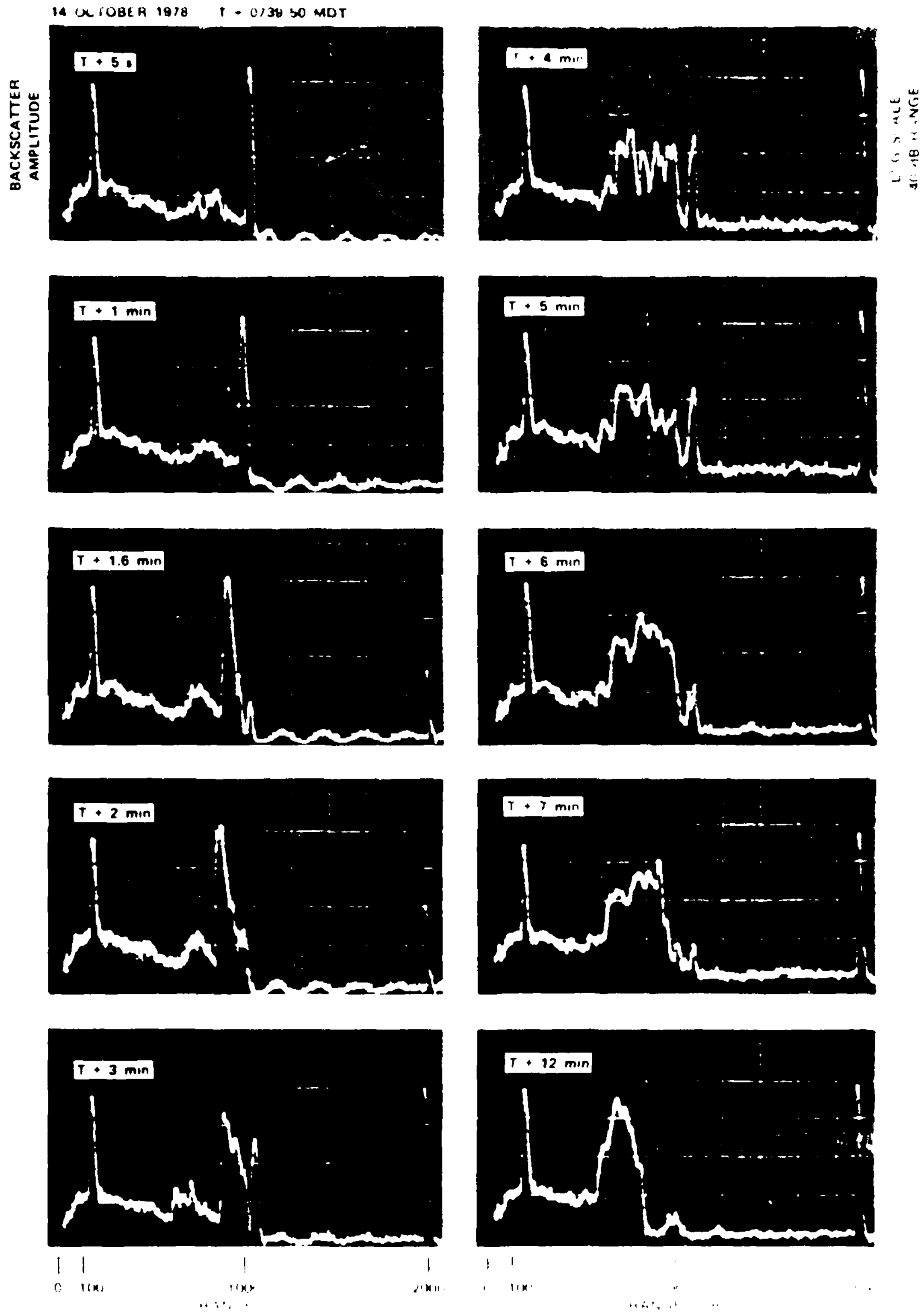


Figure 54. Difference between Ruby and CO_2 optical depths (F-8).



14 OCTOBER 1978 T = 0739 50 MDT
BACKSCATTER AMPLITUDE
T + 5 s
T + 1 min
T + 1.6 min
T + 2 min
T + 3 min
T + 4 min
T + 5 min
T + 6 min
T + 7 min
T + 12 min
0
100

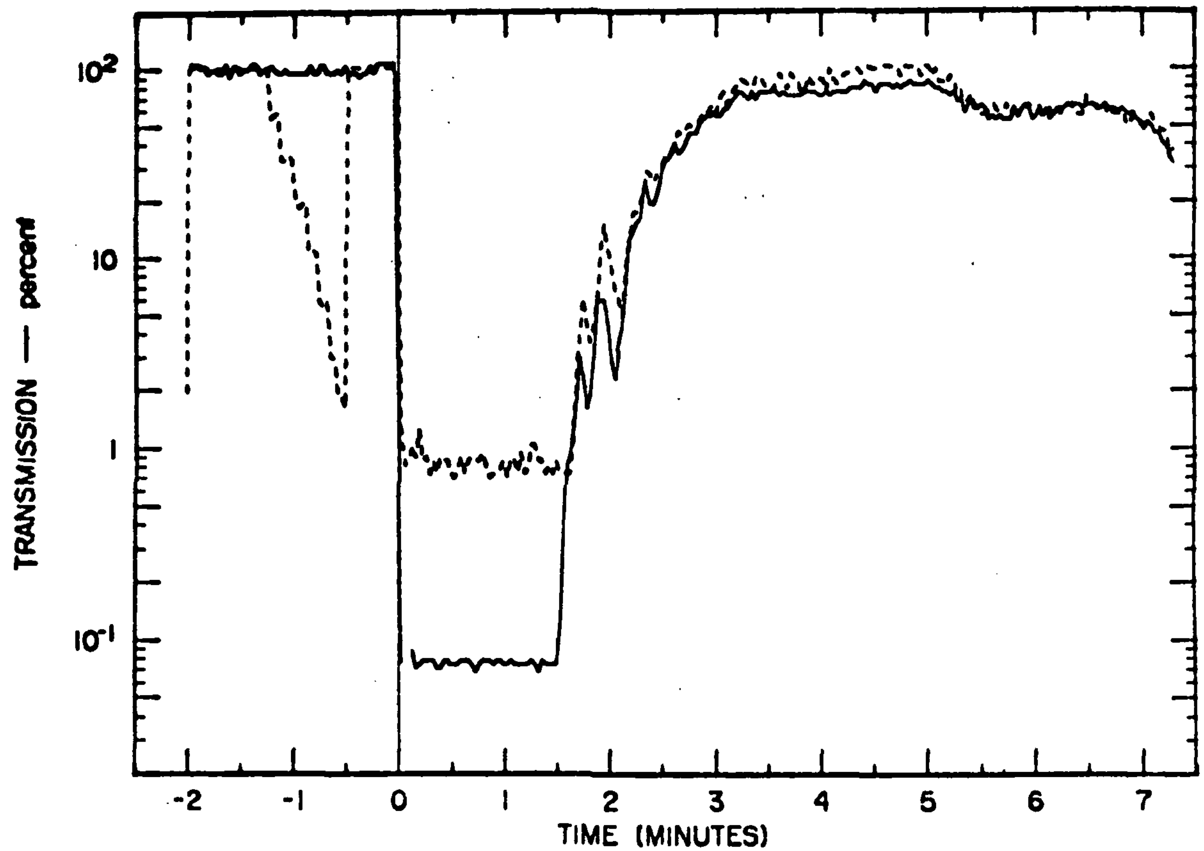


Figure 56. Transmission observed by the two-wavelength lidar system (E-5).

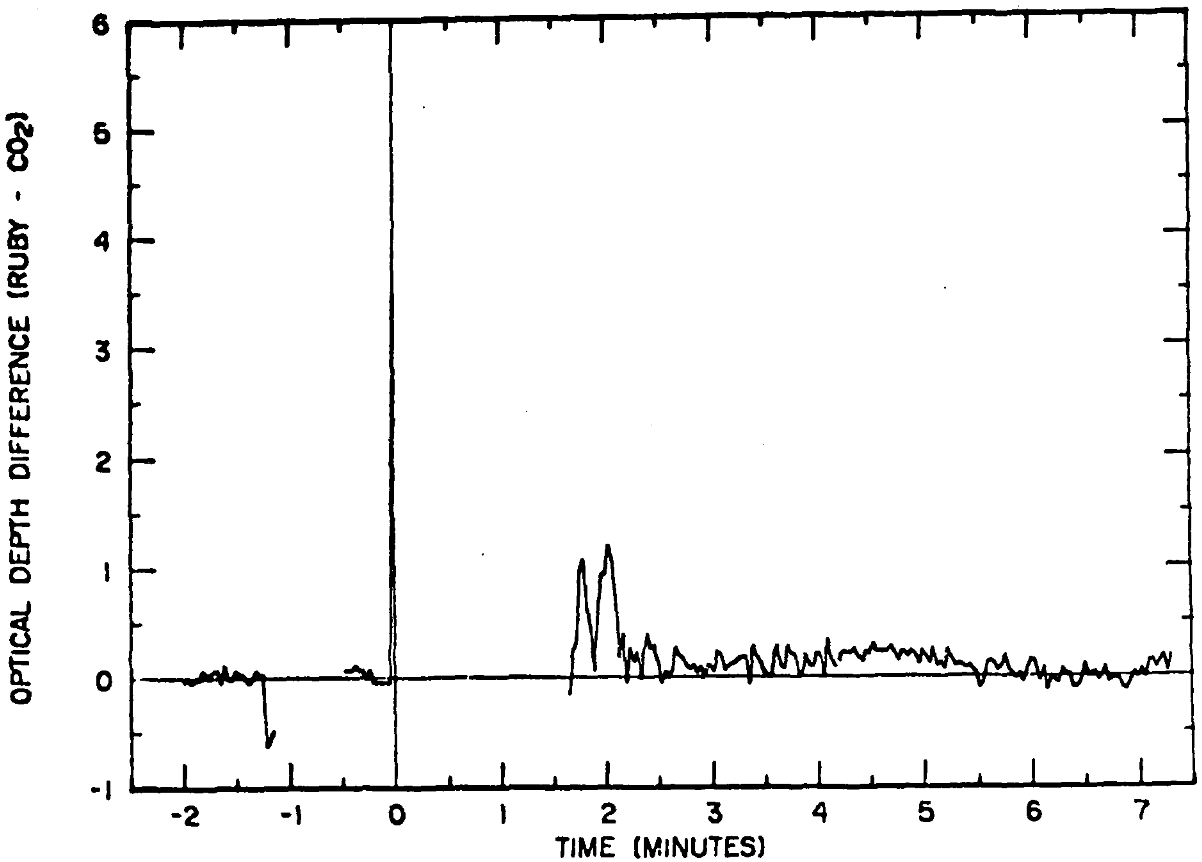
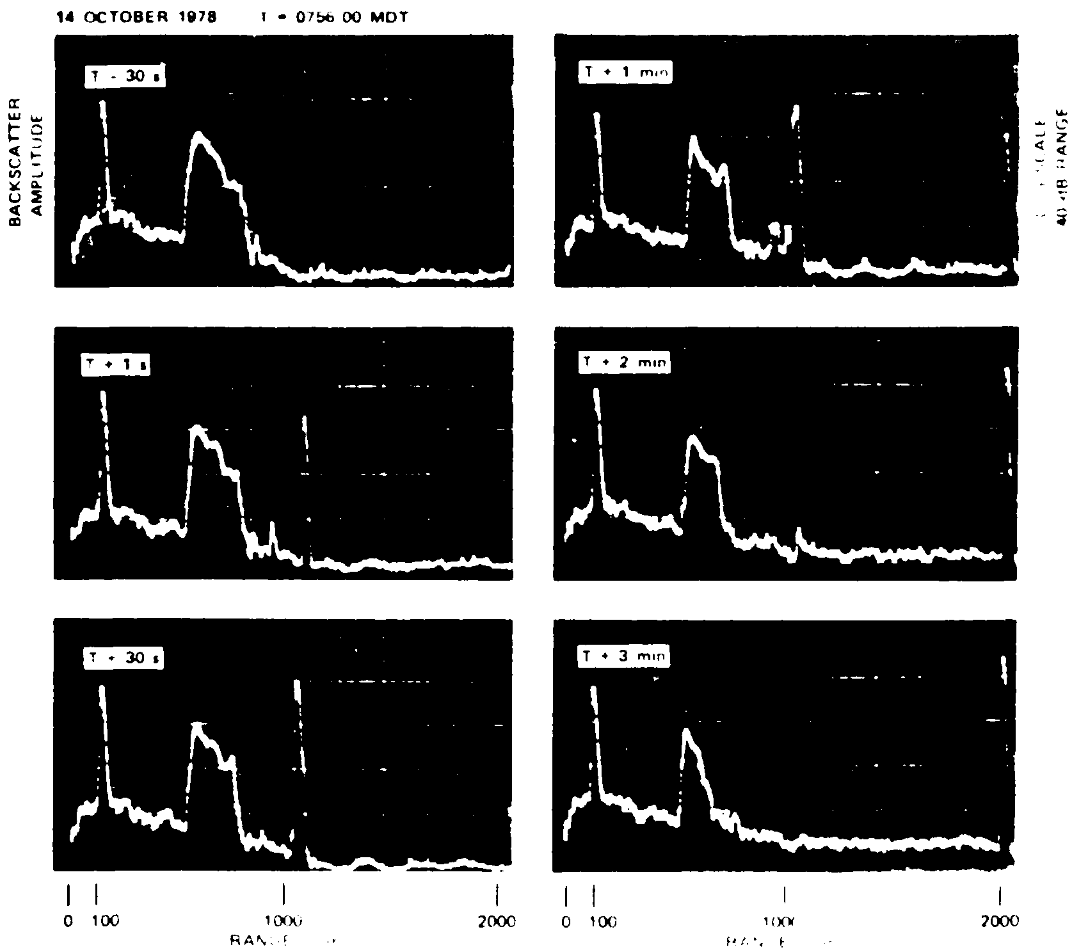


Figure 57. Difference between Ruby and CO_2 optical depths (E-[illegible]).


14 OCTOBER 1978 T = 0756 00 MDT
BACKSCATTER AMPLITUDE
40 dB RANGE
T - 30 s
T + 1 min
T + 1 s
T + 2 min
T + 30 s
T + 3 min
0
100
1000
2000
RANGE

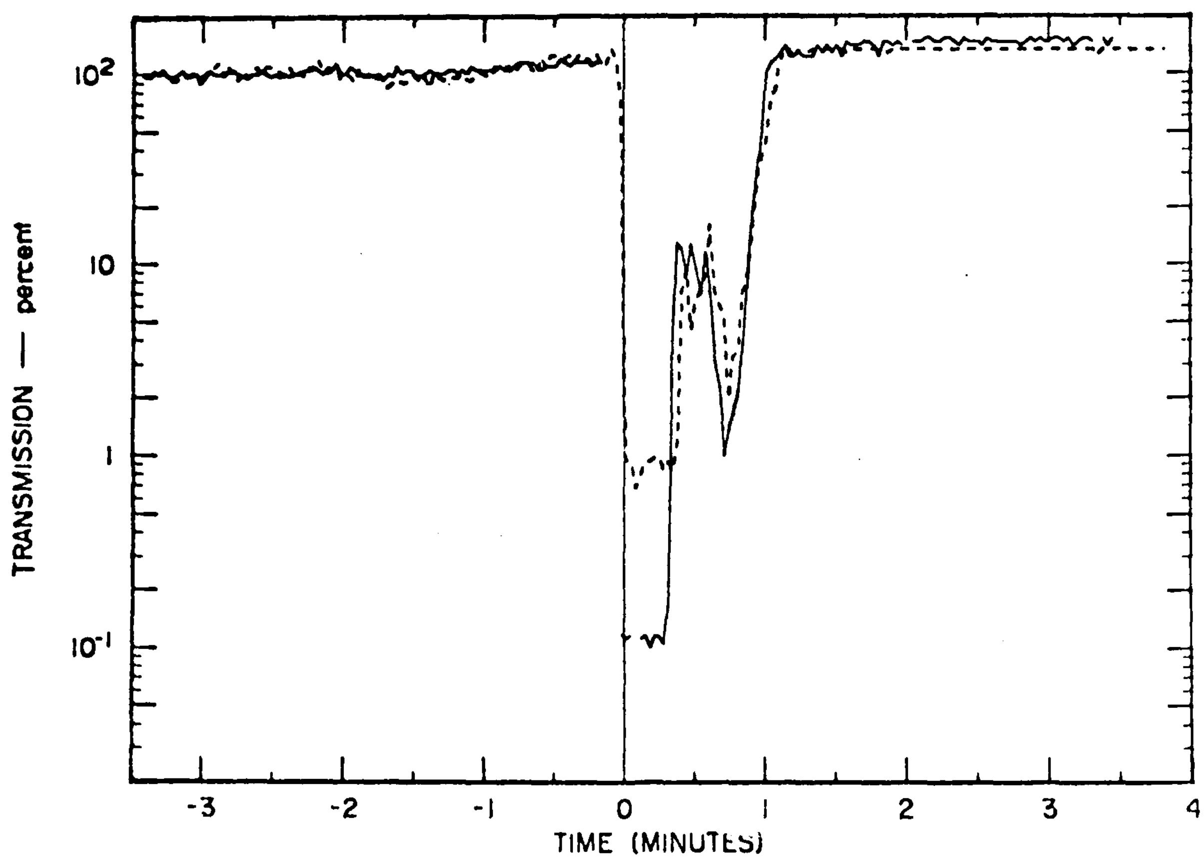


Figure 59. Transmission observed by the two-wavelength lidar system (E-6).

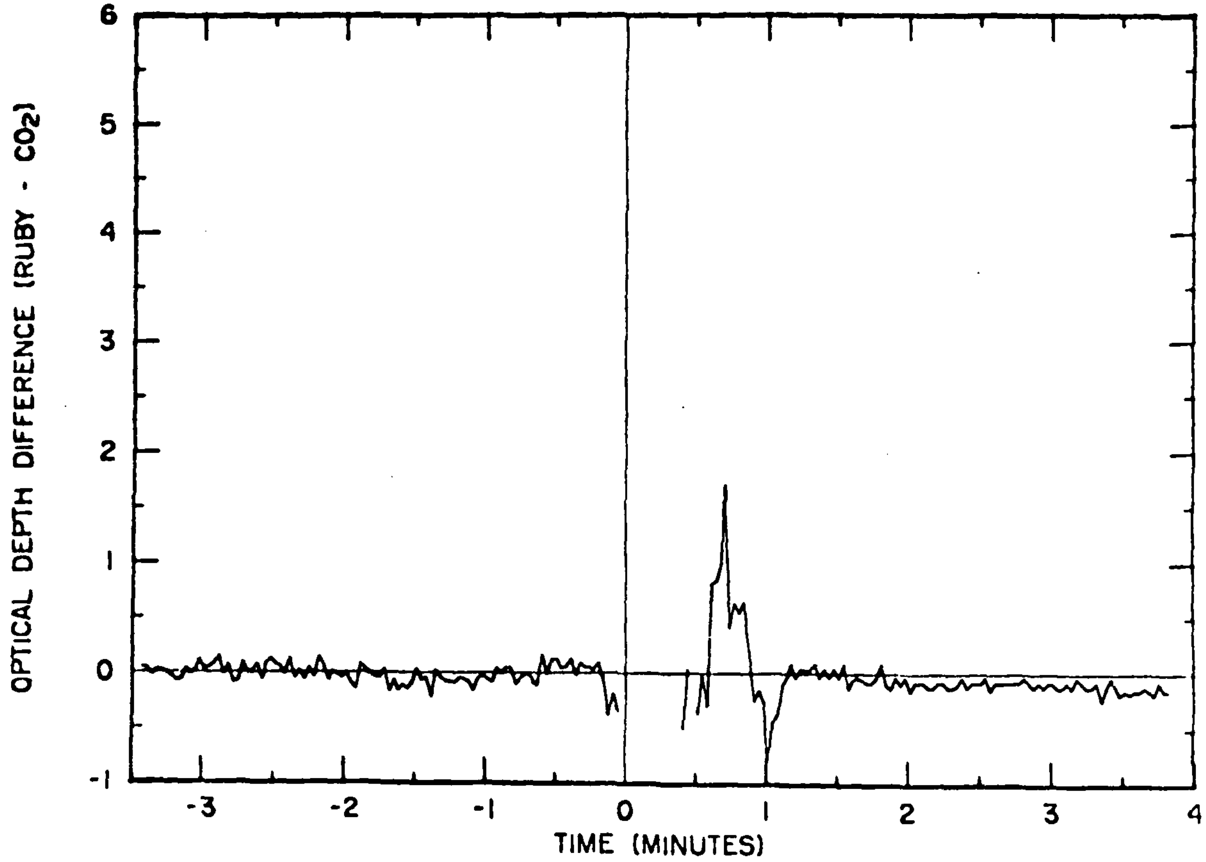
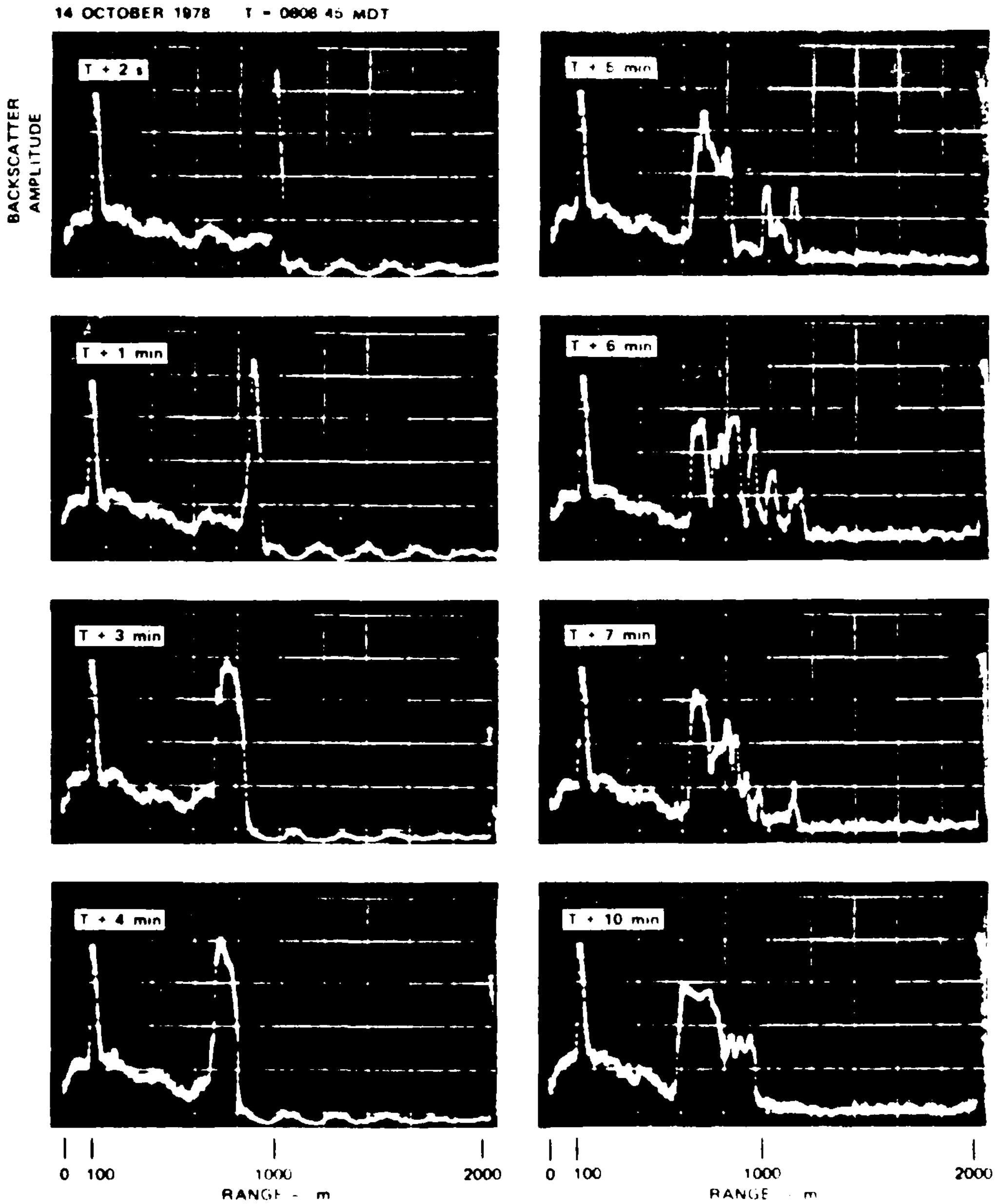


Figure 60. Difference between Ruby and CO_2 optical depths (E-6).


14 OCTOBER 1978 T = 0808 45 MDT
BACKSCATTER AMPLITUDE
T + 2 s
T + 1 min
T + 3 min
T + 4 min
T + 5 min
T + 6 min
T + 7 min
T + 10 min
0
100
1000
2000
RANGE - m

Event ... 10 ...

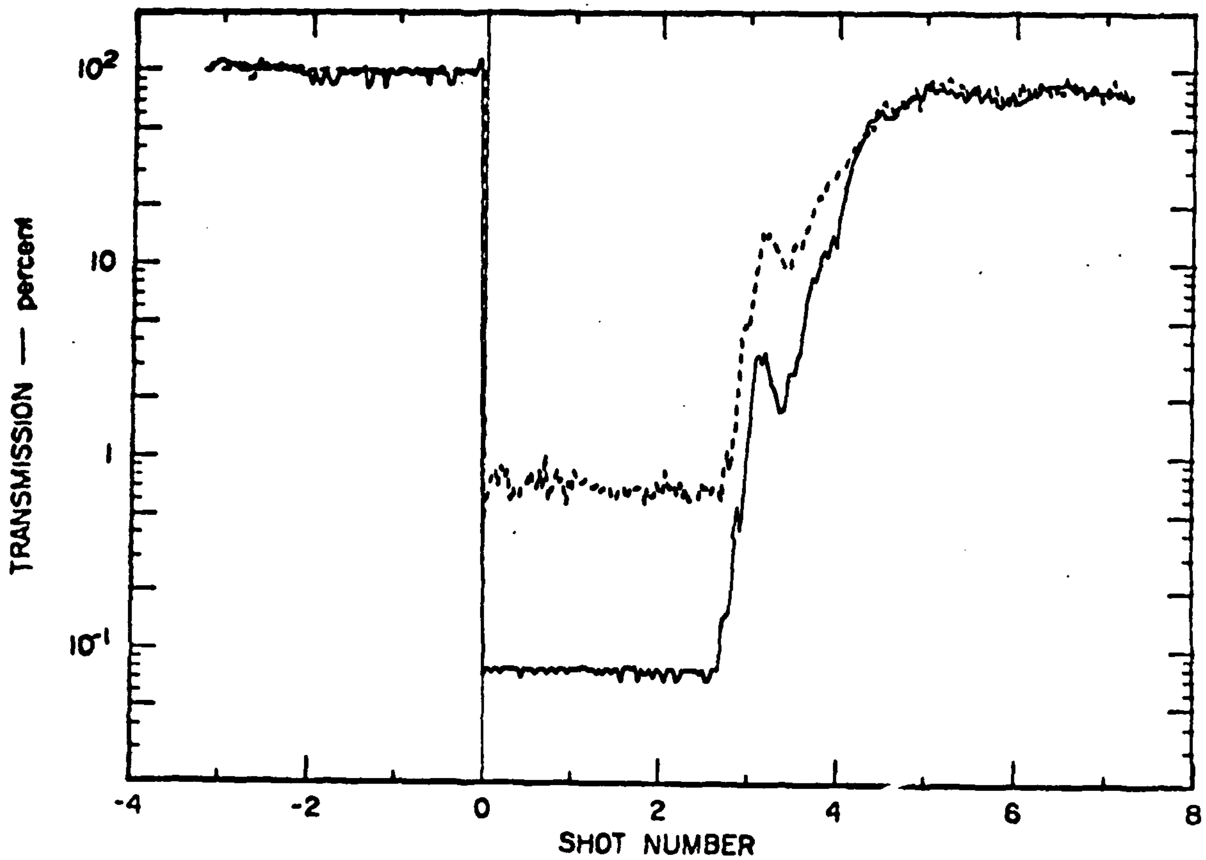


Figure 62. Transmission observed by the two-wavelength lidar system (E-7).

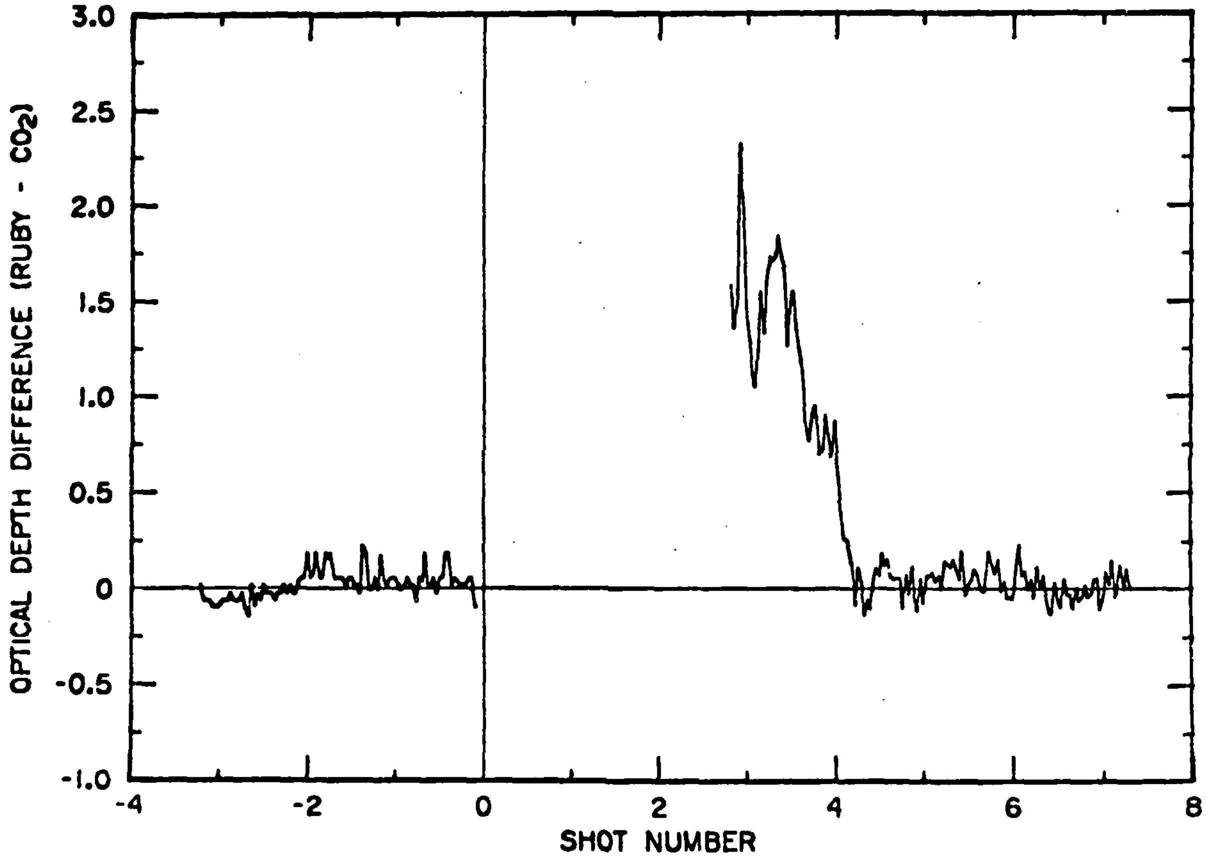


Figure 63. Difference between Ruby and CO_2 optical depths (E-7).

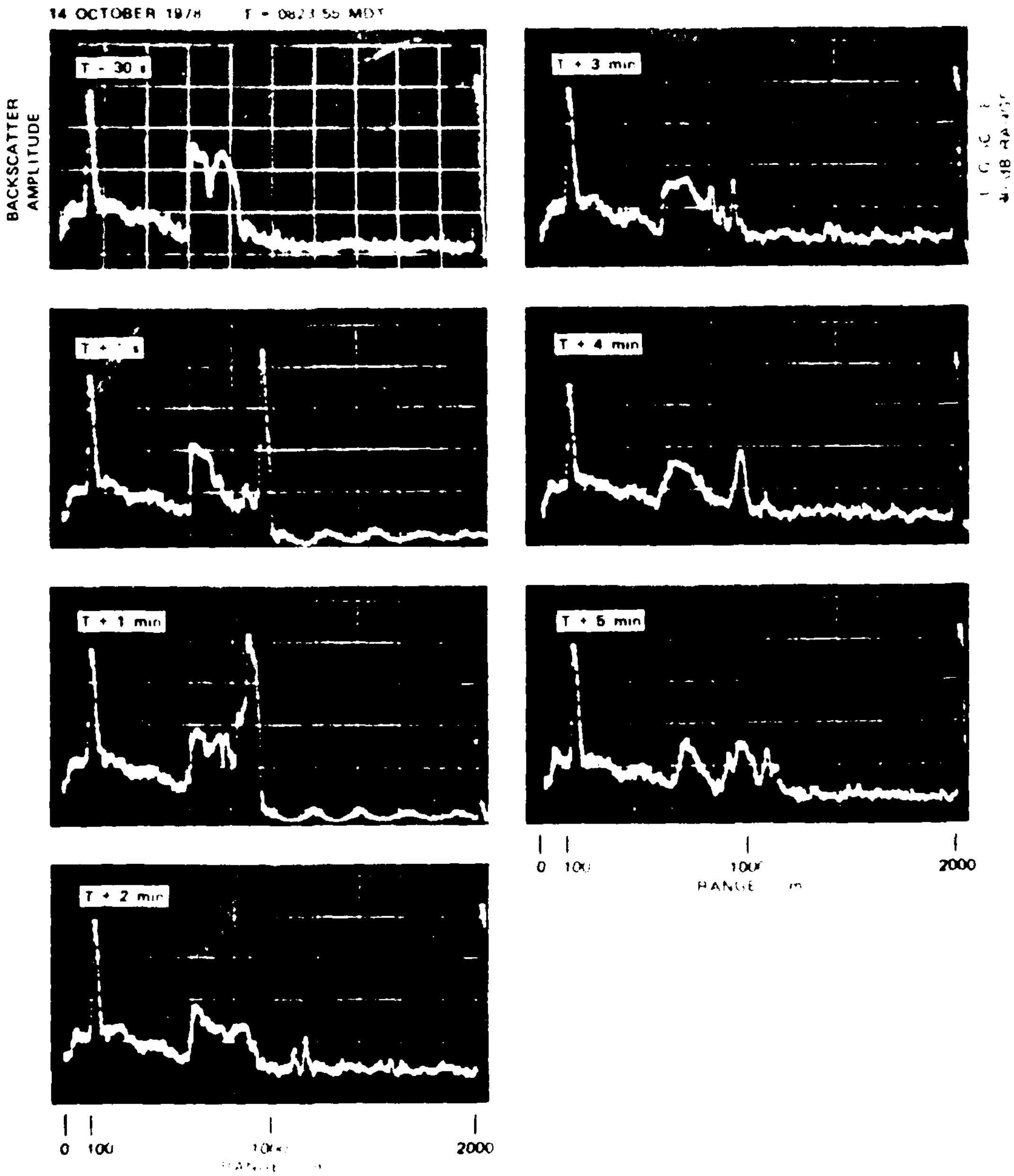


Fig. [illegible] 10.6μm backscatter data.

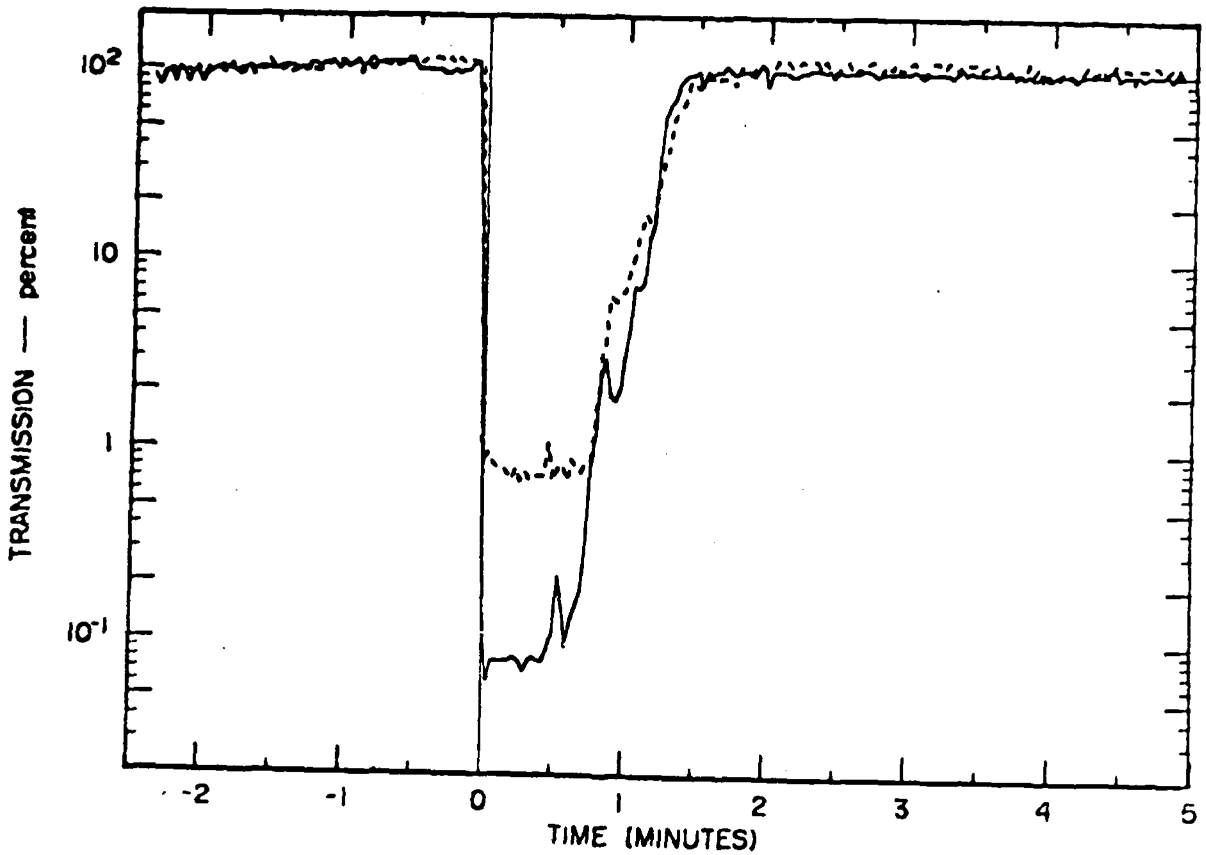


Figure 65. Transmission observed by the two-wavelength lidar system (E-8).

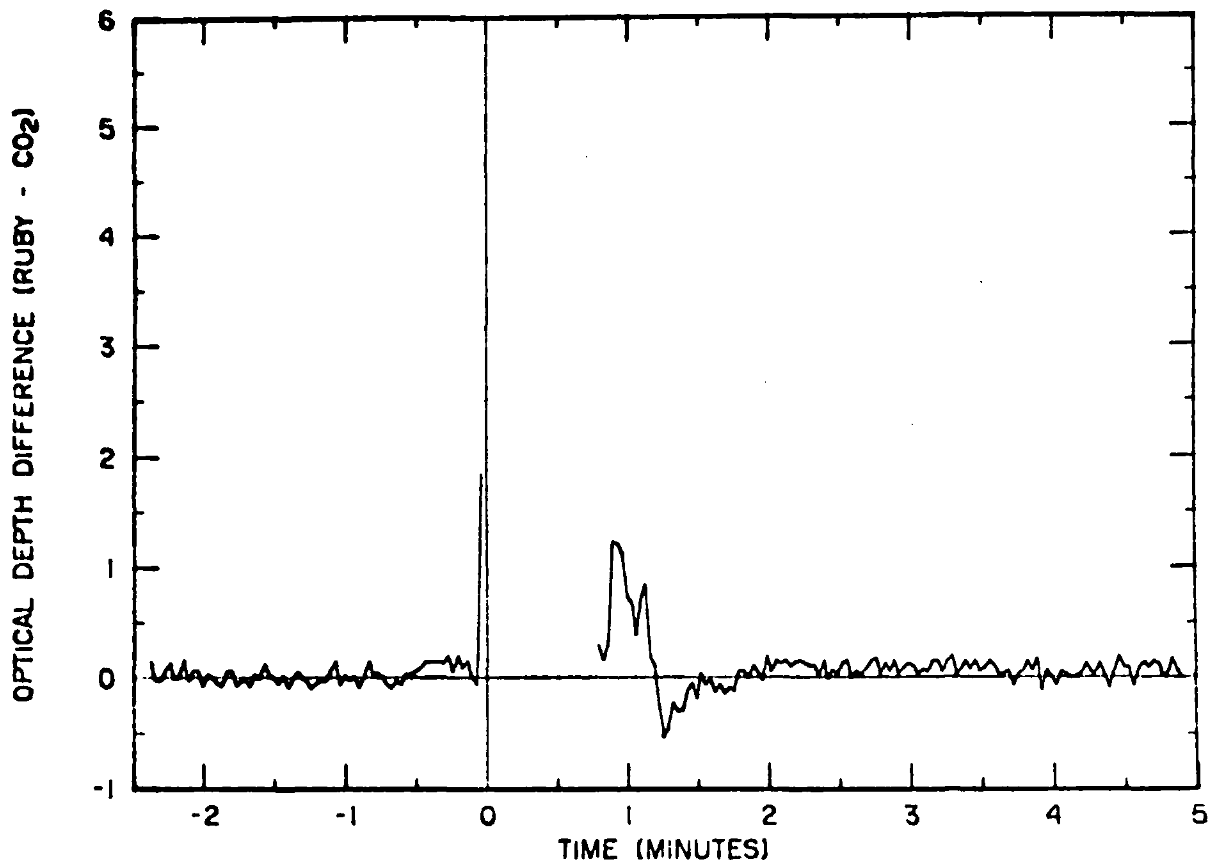


Figure 66. Difference between Ruby and CO_2 optical depths (E-8).

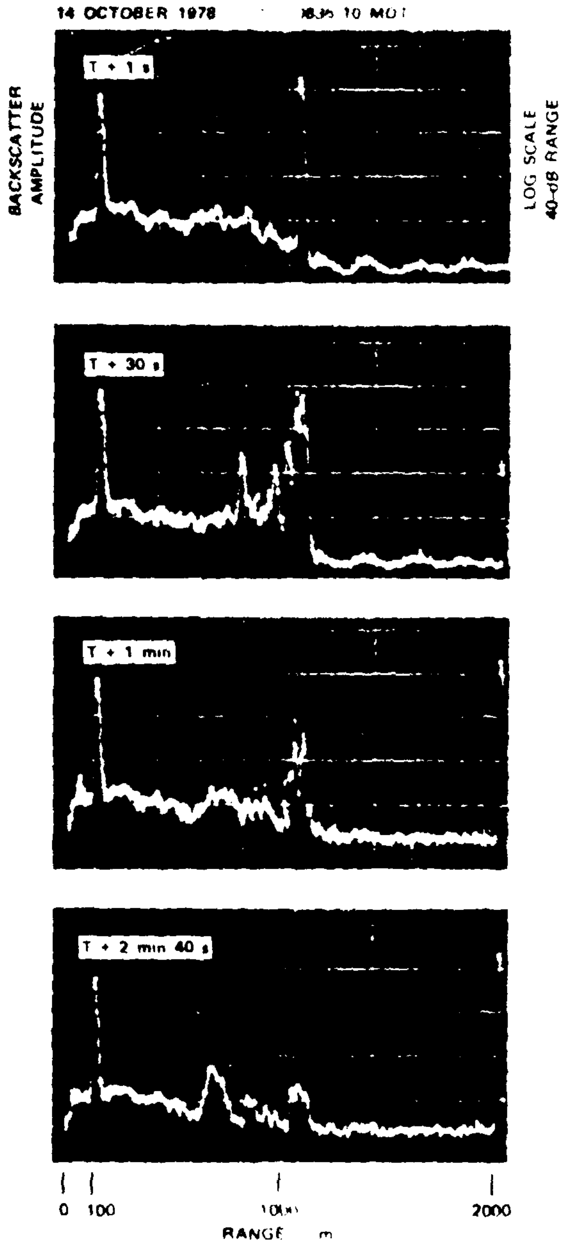


Figure 67. Event [illegible] atter data.

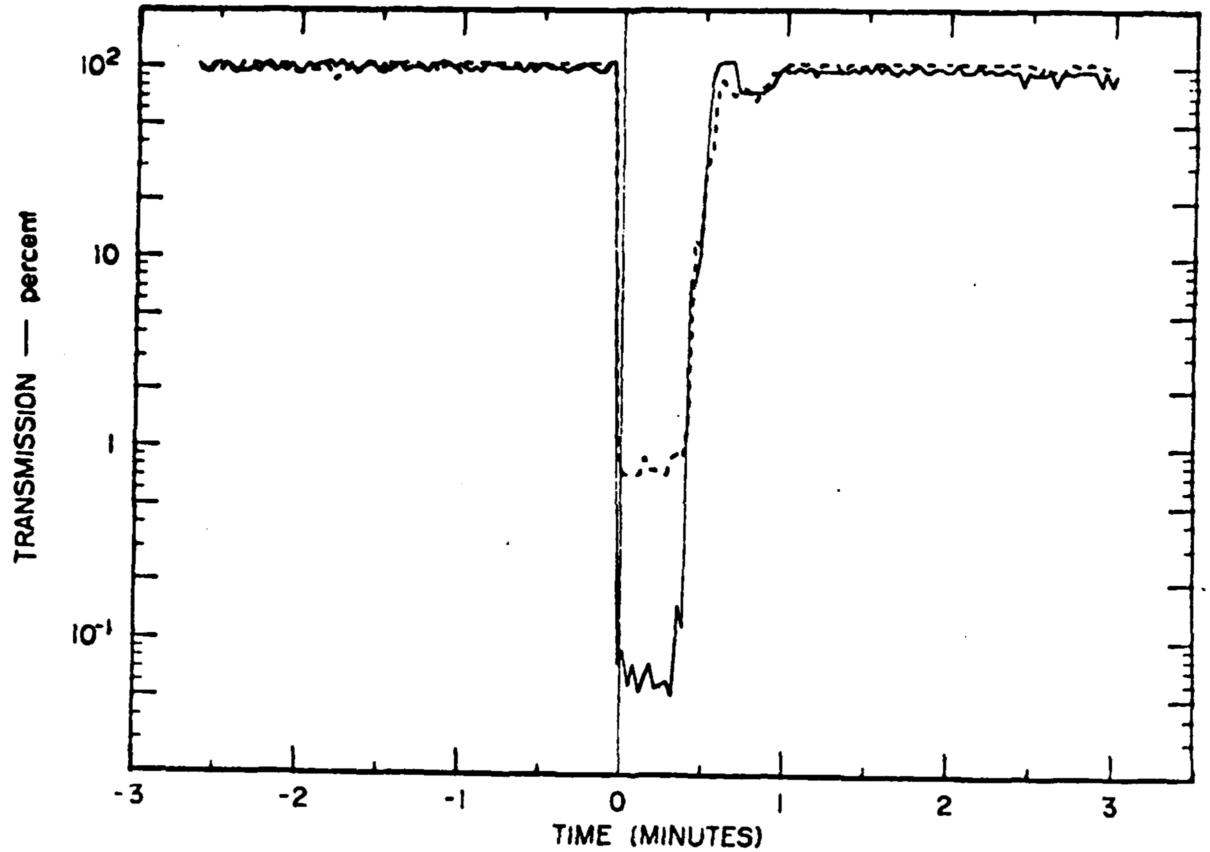


Figure 68. Transmission observed by the two-wavelength lidar system (E-9).

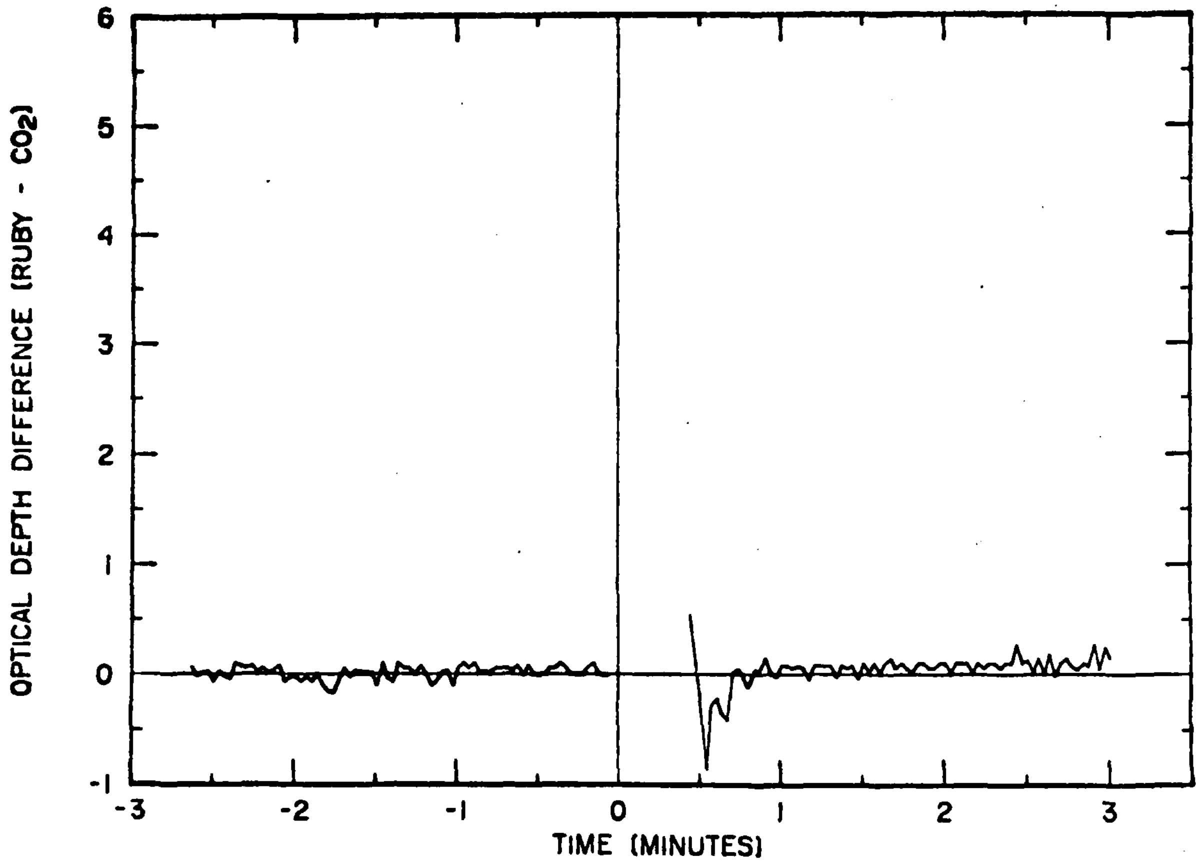
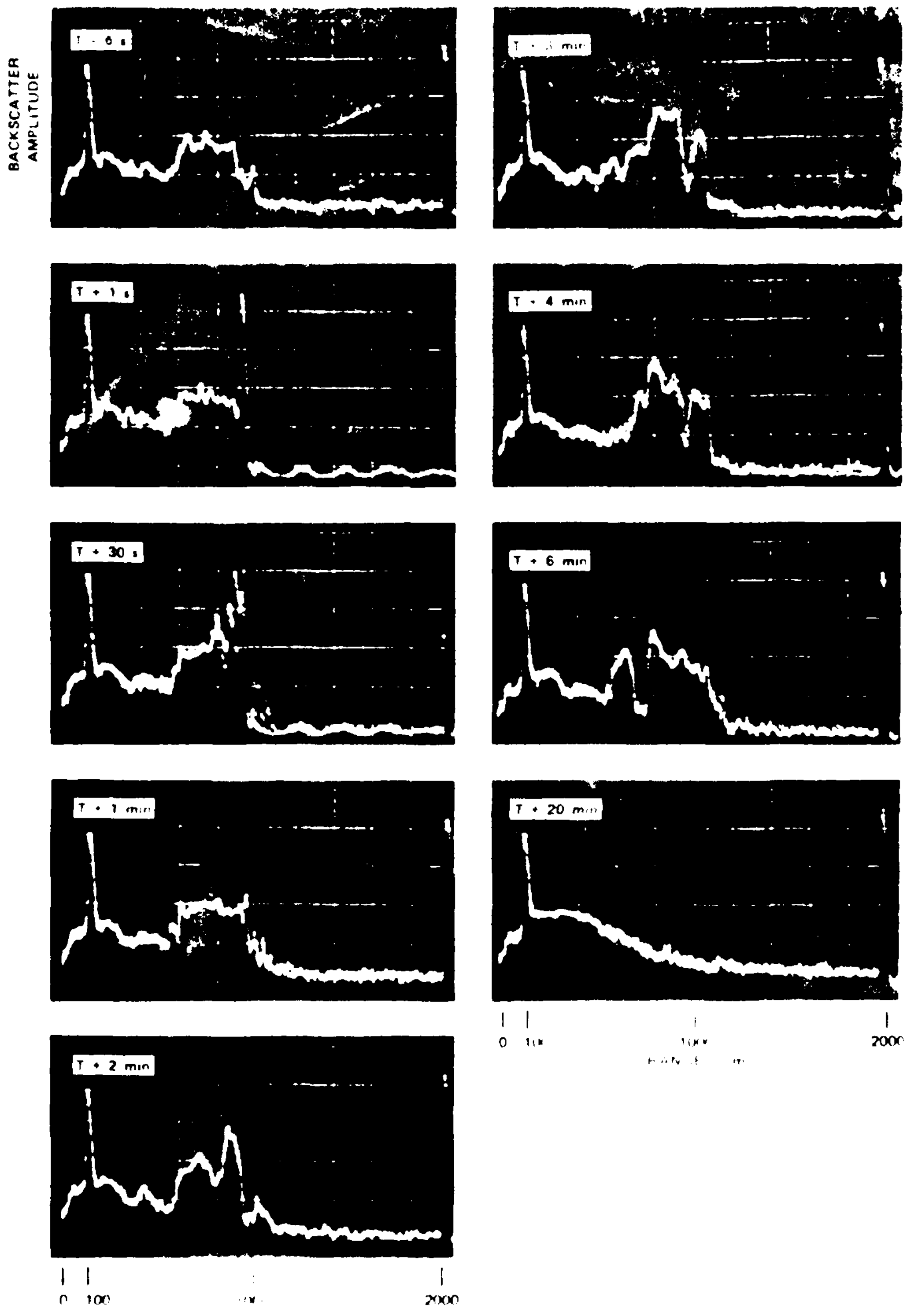


Figure 69. Difference between Ruby and CO_2 optical depths (E-9).



BACKSCATTER AMPLITUDE
T - 6 s
T + 1 s
T + 30 s
T + 1 min
T + 2 min
T + 4 min
T + 6 min
T + 20 min
0
100
2000

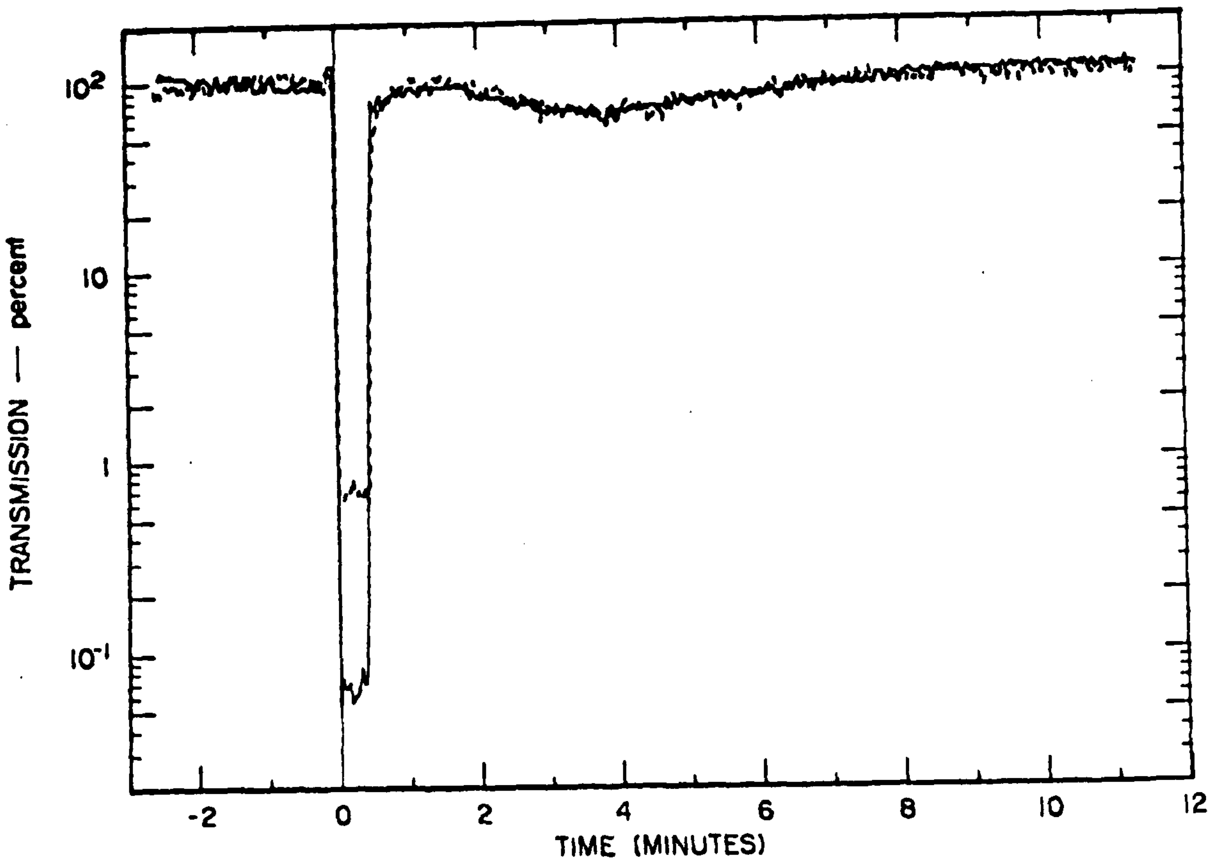


Figure 71. Transmission observed by the two-wavelength lidar system (E-10).

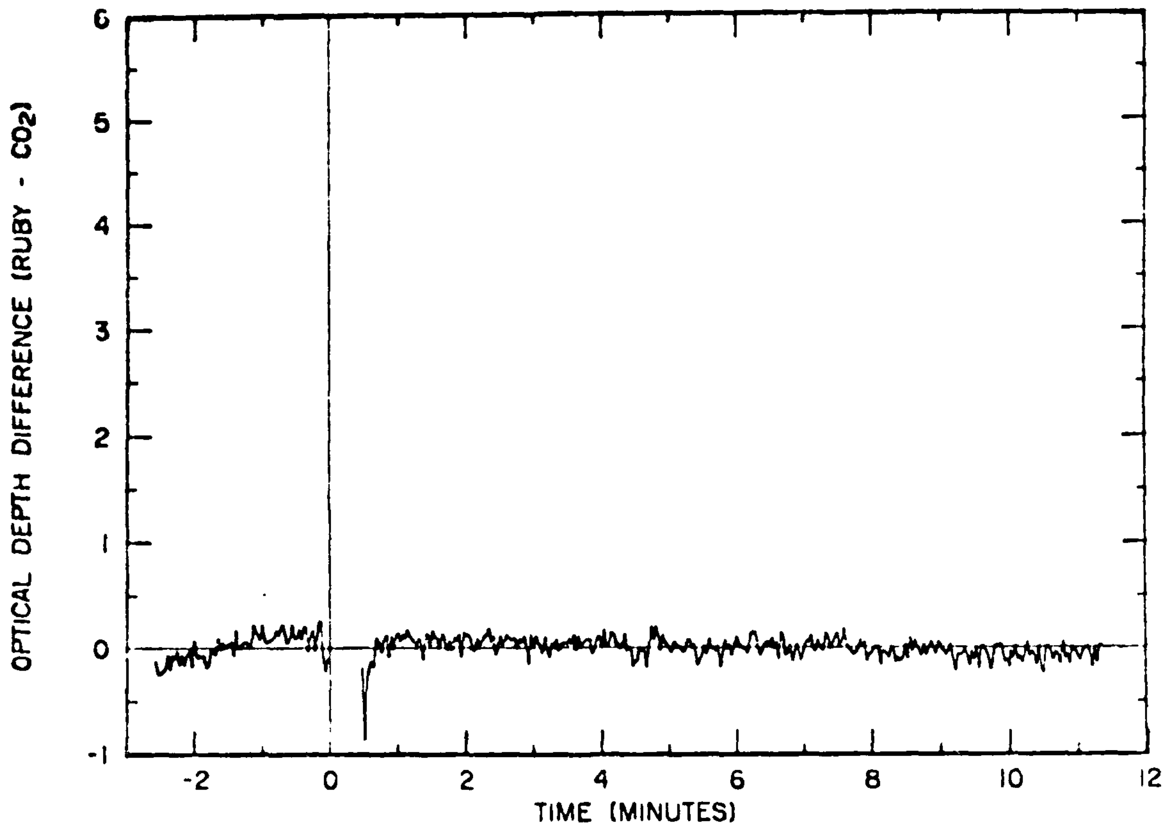


Figure 72. Difference between Ruby and CO_2 optical depths (E-10).

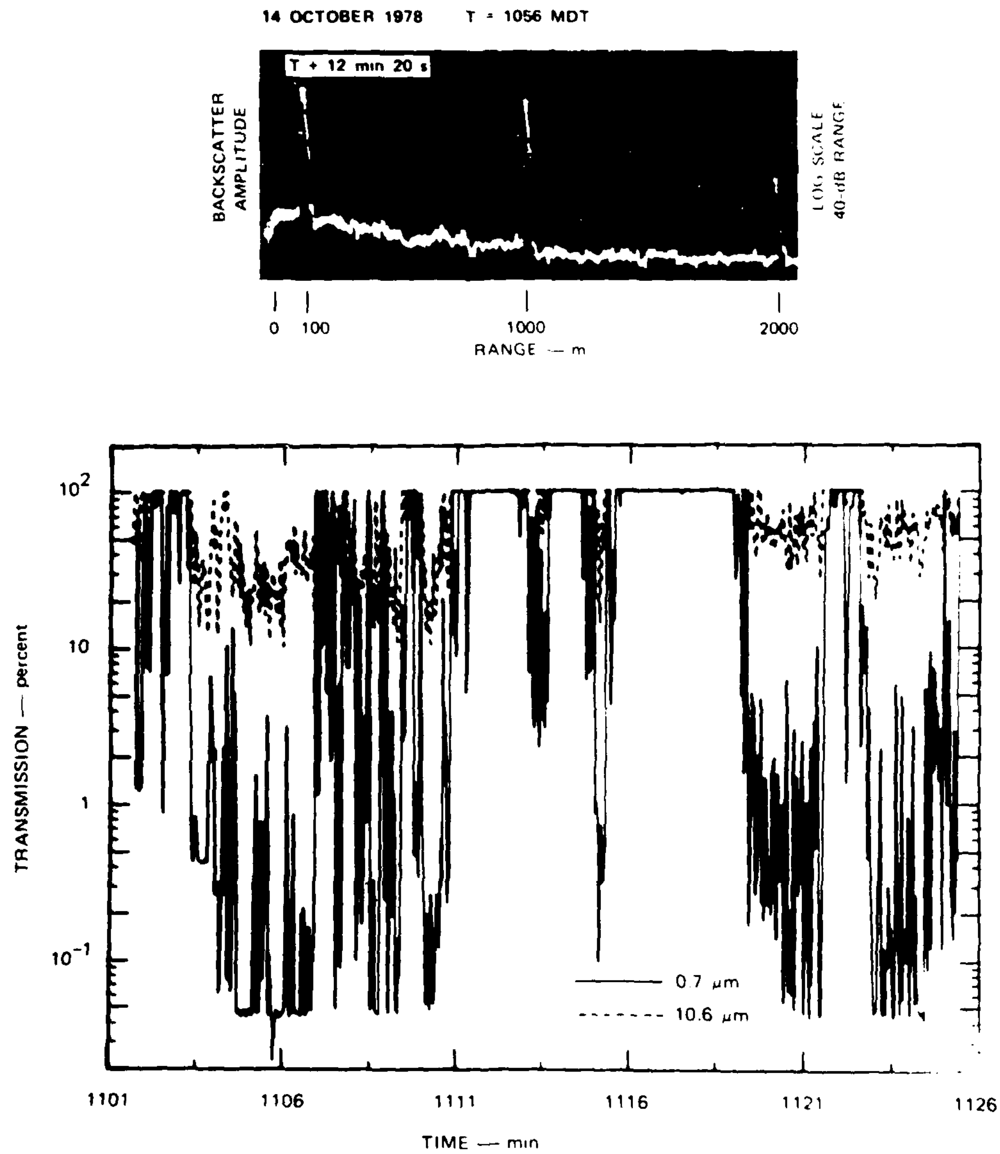


Figure 73. Event G-1 10.6μm backscatter data and two-wavelength transmission.

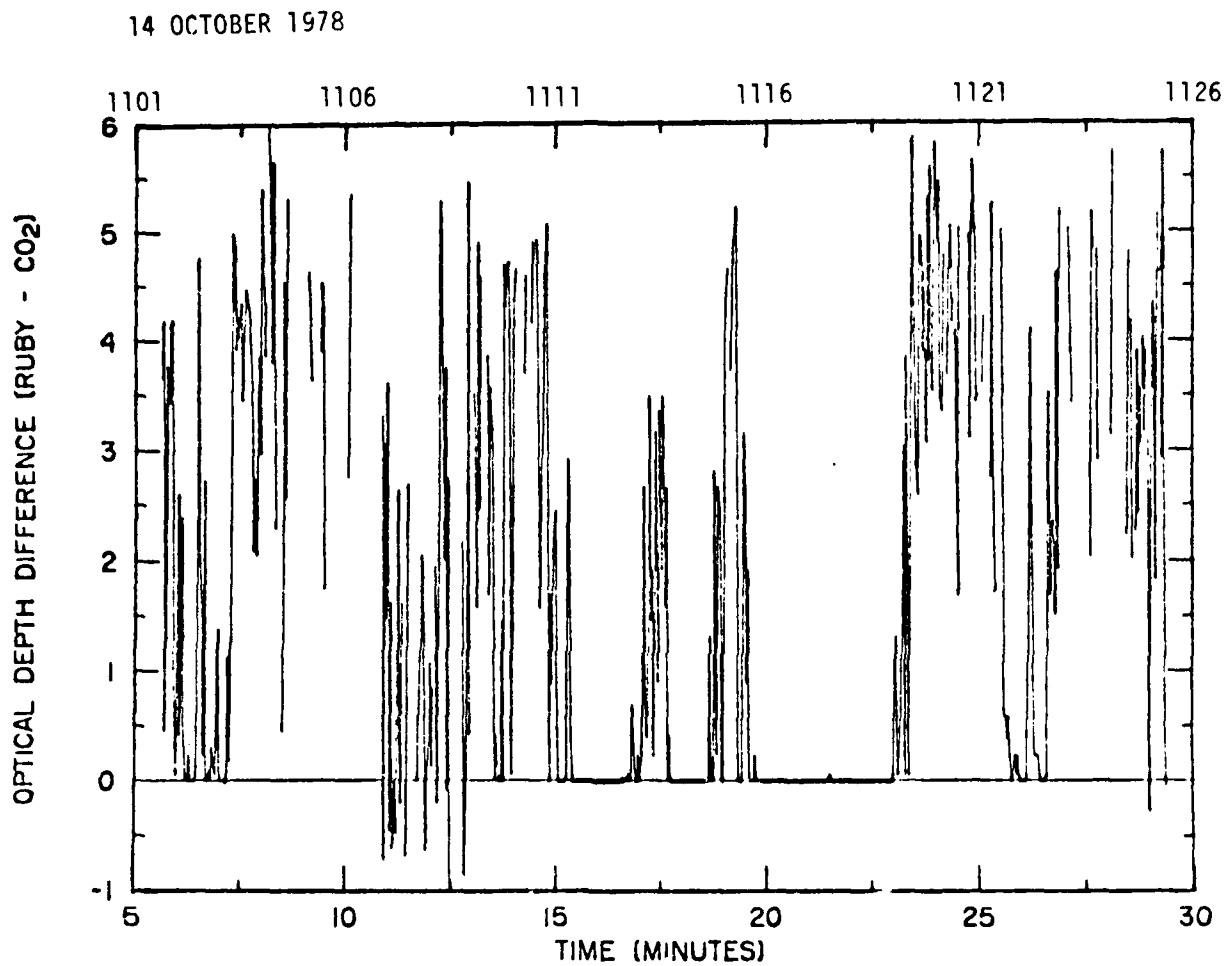


Figure 74. Difference between Ruby and CO_2 optical depths (G-1).

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1. Uthe, E. E., and R. J. Allen, 1975, "A Digital Read Time lidar Data Recording, Processing, and Display System," Optical and Quantum Electronics, 7:121.

2. Van der laan, Jan E., 1979, Lidar Observations at 0.7μm and 10.6μm Wavelengths during Dusty Infrared Test-I (DIRT-I), ASL-CR-79-0001-2, US Army Atmospheric Sciences Laboratory, White Sands Missile Range, NM.

3. Lindberg, James D., 1979, Measured Effects of Battlefield Dust and Smoke on Visible, Infrared and Millimeter Wavelength Propagation: A Preliminary Report on Dusty Infrared Test-I (DIRT-I), ASL Technical Report 0021, US Army Atmospheric Sciences Laboratory, White Sands Missile Range, NM.

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